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Japan

THE TRENDS AND PROBLEMS OF INDUSTRIAL SCIENCE AND TECHNOLOGY

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43070024E Tokyo MITI REPORT in English Jun 92

[Towards Global Techno-Coexistence: Tentative Abridged Translation]

CONTENTS

ERRATUM: In JPRS-JST-92-021 of 14 August 1992, SURVEY REPORT ON RESEARCH ACTIVITIES IN PRIVATE ENTERPRISES, the next-to-last sentence on p. 19 should read: When we asked those firms that export technology whether or not their trading partners were subsidiaries, 43% replied that their technology trade was with "nonsubsidiaries only," and 27% said "mostly nonsubsidiaries."

The Trends and Problems of Industrial Science and Technology

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[Text]

Chapter I Areas of Industrial/Scientific Technology

1. World-wide Growth of Expectations for Industrial/Scientific Technology

Industrial/scientific technology[1] has contributed to the development of society of mankind. It has influenced not only economic and industrial activities but also the structure of society and the lifestyle of people. Recent remarkable progress in technology has made it the focus of much attention as an important factor for the development of companies and nations.

With the prospect of gaining an advantage in market competition among companies and strengthening industrial competitiveness of nations, scientific and technological activities are being managed all the more vigorously both at a company and at a national level. More and more attention internationally is now being focused on technology, as it gains more importance as a basis for national power in the post-cold war world.

On the other hand, industrial/scientific technology in the pursuit of efficiency has come to a turning point, as the world becomes smaller and the problems of environmental issues and energy resources take on global significance. Construction of a new system of technology that is favorable both to people and the environment must be pursued as a global issue, so that it may lead to harmony between mankind and nature, as well as an acceptable standard of living.

2. Increased Global Interdependence in Scientific and Technological Activities and the Need for International Discussion from a Political Viewpoint

The promotion for industrial/scientific technology is a common concern of all nations. Every government is developing policies to this aim. These policies have distinct features unique to each country, reflecting the economy, industrial structure and the system of research and development employed by each country.

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[1] Industrial/scientific technology: The interaction between industrial technology and science has been increasing. The progress of science promotes the development of industrial technology, and new technologies stimulate scientific studies. No clear distinction can now be made between industrial technology and science, as these two are not evolving independently of each other. In this writing, "industrial technology" and "science and technology" are treated as a indivisible, and the term "industrial/scientific technology" is meant to include both.

On the other hand, globalization of activities in the field of science and technology, as well as industry, has been increasing the global interdependence of countries in terms of industrial/scientific technology. Much attention is directed to the consequence of these changes in the scientific and technological activities and related policies in each country.

As the basis for considering this, it is necessary to understand the present profile and future development of industrial/scientific technology in each country, as well as the reality of global interdependence.

3. Growth of International Attention to Japanese Industrial/Scientific Technology

As the importance of science and technology gains increasing recognition, foreign countries voice concerns that Japan is not thorough enough in sending out the results of basic studies and that they are not provided with sufficient access to science and technology in Japan. A common criticism is that the access to research and development conducted by the private sector is particularly hindered because of intellectual property rights and other barriers. For these reasons, critics of Japan's "free ride on basic studies", claim that the Japanese are eager to utilize the fruits of basic studies without any fundamental contribution of their own. At the same time, there is much positive recognition of Japan's achievements from all over the world. Many countries wish to learn from the high performance results of Japanese industrial/scientific technology and the experience of Japanese people in developing such technology..

In response both to the criticisms and the appreciation, Japan must try to convey clearly the actual state of its industrial/ scientific technology, so that it can continue its role of sending out technical information to the world.

4. Need for Globally Acceptable Policies on Industrial/Scientific Technology

Industrial/scientific technology activities cannot be completed wholly within the border of a country. Policies related to these activities are increasingly taking on international significance and must always be considered from a global perspective. In other words, there is a growing recognition of the concept of techno-globalism where related policies should be developed with the purpose of maximizing the benefit of science and technology to the people all over the world. This is a concept that should be promoted with international cooperation and coordination. There is a need to clarify the foundation and the contents of this concept.

Chapter II Actual State of Industrial/Scientific Technology and the Position of Japan

Section 1 Roles of Industrial/Scientific Technology in the Past

Industrial/scientific technology has contributed to both the economic and social development of mankind. The Economic White Paper of 1990 examined the influence of technological advancement on the economic growth of Japan, categorizing growth into three elements attributable to capital, labor, and technological advancement. According to this analysis, the average annual growth of 4.8% recorded over the past two decades (1970-89) included a contribution of 1.5% from technological advancement, the second largest factor following capital. From 1980 to 89, while the average annual growth decreased to 4.5%, the contribution from technological advancement increased slightly to 1.7%. The White Paper compared similar analysis of economic growth between Japan and the U.S. It was concluded that technological advancement played a greater role in the economic growth of Japan than in the U.S.

Similar findings were obtained from an analysis of techno-stock, which was conducted to identify the influence of technological accumulation on economic development. Fig. 1-1 compares Japanese Commercially Oriented R&D techno-stock (Stock of technological knowledge) with that of the U.S. Although Japanese techno-stock of this type has been increasing gradually, it is still only about 20% of that in the U.S. It should be noted that the slow-down of the American techno-stock is due to the changes in foreign exchange rates. When measured in dollar value, a gradual increase is also revealed in American techno-stock directly related to production.

In order to see how economic growth has been influenced by the techno-stock directly related to production, the average marginal profitability of this techno-stock (an index representing the increase in production corresponding to the increase in the techno-stock of this type by one unit) was calculated for the years from 1979 to 1988. The result gave a marginal profitability of 1.9 for the Japanese techno-stock indicating that its increase has been contributing greatly to economic growth. The fact that the index was higher than that of the U.S. (1.6) suggests that the Japanese techno-stock has been working more effectively for economic growth.

Besides the contribution to economic growth, industrial/scientific technology has played an important role in the achievement of the needs of people and the realizations of an affluent society.

Post-war advancement of automation and the establishment of mass-production technology provided the Japanese with material affluence. The so-called "three status symbols " of the post-war period namely a washer, a refrigerator and a television set, reached every household. While large families were being replaced by small families, industrial/ scientific technology played an important role in reducing the working hours of housewives, as well as providing pleasure. After 1965, the high growth of the national economy and the improvements in income triggered the pursuit of affluence. Cars, air conditioners and color TV sets became popular. After 1975, the establishment of the technology for multi-model small-lot production enabled a more sophisticated response to the diversified and individualized needs of consumers (Table 1-1).

In an opinion poll conducted by the Prime Minister's Office in 1990, 76% of Japanese people answered that the advancement of science and technology improved the standard of living (Fig. 1-2). It is a common understanding of the Japanese people that the advancement of technology has played an important role in the improvement in the life of people.

Section 2 Actual State of Industrial/Scientific Technology

Subsection 1 Technological Innovation Processes and Creativity in Industrial/Scientific Technology

(1) Diversity of Technological Innovation Processes

a) Technological Innovation Processes

Just as industrial/scientific technology has various features reflecting the course of its historical development, the process of the innovation of a specific technology is influenced by various factors. Human resources committed to R&D of the technology, wages, and various research infrastructures are input factors for the development technology. On the other hand, external factors (with regard to the technology) include

the general level of technology, the structure of the industry, market characteristics, available energy and resources and the natural environment.

The process of technological innovation may be considered to have a dynamism in which input factors bear fruit in technological innovations, the technological innovation contributes to the improvement of external conditions, and the improvement of external conditions stimulates the improvement of input-side factors. External conditions for a specific technology differ greatly between different countries. Therefore, the process of technological innovation is considered to have varying features in each different country.

In conventional theories, the process of technological innovation (such as the development of a new product, introduction of a new production method, etc.) is often described as a linear path from the basic study giving rise to new scientific knowledge learning up to application studies, development studies, and commercialization (linear model: Fig. 2-1). Such a model gives the impression that basic studies have critical importance in technological innovation (or, in other words, technological innovation cannot occur without basic studies).

The recognition that "basic studies are the capital of science" in this theory exerts a great influence on the planning of science and technology policies in Western countries. In the United States, the National Science Foundation (NSF) was established in 1950 and was based on this recognition.

However, the linear model does not consider the conditions of the external environment, such as market characteristics, which influence technological innovation. The actual process of technological innovation cannot be examined without considering interactions with the external environment. From this point of view, several types of non-linear models have been proposed in theoretical studies. Examples of such models include the chain-linked model, the concurrent system model and the spiral model (Fig. 2-2).

The chain-linked model organizes the processes of technological innovation along a flow line from the discovery of a market to distribution and sales. It emphasizes the importance of interactions and feedback occurring amongst the processes. In this model, research and development are positioned in a parallel process conducted by a separate organization. The process of development related to technological innovation not only

utilizes existing knowledge but also procures new knowledge, if necessary, through the initiation of new studies. Basic and applicational studies in this model are understood as the provider of a knowledge base required by the whole process of R&D.

The concurrent system model assumes that the processes of research, development, production, and marketing exist together. Sharing of information among these processes facilitates rapid promotion of technological innovation. This model emphasizes the importance of the sharing of information among organizations conducting these processes and the linkages between them. A powerful product manager group controlling each process is assumed to play this role. The organization growth model has evolved from this model. Not only information but also persons holding information are moved among organizations according to the progress of the project. The organizations are expanded accordingly so that the accumulation of technologies is facilitated.

The spiral model derives from the observation that the course of technological innovation consists of development cycles. The key point of this model is the incorporation of the idea that the discovery of market needs and subsequent technological developments occur in alternate cycles.

As outlined above, the processes of technological innovation are explained in various ways. It is difficult to explain the whole spectrum of actual processes involved in technological innovation using only a single model.

Though the processes of technological innovation are formed under the influence of various background factors, such as economic environment, market needs, and the system of R&D, they have distinct features according to the type of product and the field of business.

In fact, a questionnaire conducted with Japanese companies revealed the diversity of the processes of technological innovation. Few companies were found to have the recognition that basic studies are an important element of the process of product development.

The wide variety of technological innovation processes outlined here indicates that scientific knowledge and the source of technology do not spontaneously lead to new technologies and new products. Rather, what are important are creative activities in

which market needs are grasped accurately and then fulfilled. It is also suggested that these processes are flexible in response to the changes of industrial/scientific technology itself, as well as the changes in the conditions of the external environment.

b) Process of Acquiring New Technologies

Acquiring new technologies is an important element of technical innovation. Fig. 2-3 is a schematic representation of this process. Elimination of the gap between needs and seeds must be attempted both on the side of the seeds, or the provider of technologies, and of the needs, or the users wishing to utilize technologies. To promote this effort efficiently, the providers of the technology must present its application in the widest possible context (elongate the branches from the seeds), and the users must expand their field of view to include various new technology options (expand the net of the needs). Once the utilization of a certain technology is recognized to have some possibility (the overlap between the branches from the seeds and the net of the needs) through the efforts of both parties, further R&D must be conducted before the actual employment of the technology. It is usually the case that a gap exists between the seeds and the needs and the minimization of this gap through the efforts of both parties is a major precondition for acquiring new technology options.

In order to be able to promote these processes for acquiring new technologies, each company must diversify and sophisticate its technology. It is also necessary that a company enhances its basic capabilities so that it can have flexibility to respond to the appearance of new technologies.

c) Technology Fusion and Versatile Technologies

In seeking opportunities from technological innovation, it is often assumed to be found in the form of a germ of a new technology or a novel idea. However, these forms of technological seeds are not always necessary for the promotion of innovation. A common factor in successful cases of technological innovation is the clear identification of market needs and the concrete determination of the functions and specifications of goods and technologies to be developed. Recently, many cases of the creation of new technologies consists of the interaction between technologies from different fields (technology fusion) and the utilization of a technology in various fields (versatile use of technology).

An analysis of patents indicates the increasing trend toward the versatile use of technologies. While each patent is labeled with an IPC code[2], which indicates the field of technology where the invention is expected to be used most widely (main classification), additional IPC codes are given to patents which are expected to be used in different fields of technology (subclassifications). The ratio of patents having subclassifications has increased steadily, and now nearly 80% of patents have subclassifications (Fig. 2-4).

Companies are promoting the diversification of investment in research activities, so that they can flexibly and smoothly promote the acquisition of new technologies and technology fusion. Fig. 2-5 compares the situation in each industry between 1979 and 1990. The abscissa represents the expenditures committed to the field of technology related to the main business of the company, as a percentage of the total R&D investment in each industry. The ordinate represents the number of technological fields where patent applications were made per year, as a percentage of the total number of technological classifications. The data shows that an increasingly large percentage of investment is made in the fields which are not the main area of business, and patent applications are made in increasingly wider fields of technology. This indicates the diversification in the technological development pursued in each industry.

(2) Creativity in Japanese Industrial/Scientific Technology

a) Fierce Competition between Companies

Fierce competition between companies provides strong motivation for technological development. Competition has exerted strong influence on technological innovation in Japan.

Fig. 2-6 illustrates the top ten Japanese and American companies in each industry. Both for Japan and for the U.S., the sales figures for each company is measured against the figures for the company having the largest sales in each industry, which has the standard value of 100. In comparison with the U.S., the size of the Japan's top companies tend to be comparable to that of the largest company in each industry. An analysis based

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[2]IPC: International Patent Classification

on products (Table 2-1) reveals that many companies are competing with the same product.

This competitive environment has great influence on the motivation for technological development in companies. Fig. 2-7 shows the results of a questionnaire given to representative Japanese companies. As many as 36% of responding companies indicated that "competition with other companies" is the main incentive for technological development. The percentage was almost the same as that of the companies referring to "user needs."

The influence of competition on technological development has positive and negative aspects. Under the positive influence of competition, companies develop products reflecting the needs of users. A competitive environment can promote the exploration of new frontiers. The negative influence includes the excessive shortening of the commercial life-cycle of goods, too much effort for trivial changes and product discrimination and wasted time for engineering and research staff due to redundant investment in R&D.

b) Close Feed-back and the Importance of Materialization

Generally, one of the features of technological development in Japan is the close feedback between each phase in the process from R&D to the completion of the commercial product. In this process, the movement of technical information is facilitated by the movement of persons carrying the information.

Fig. 2-8 shows the result of a questionnaire concerning the transfer of technical information among the phases of basic study, application study, product development, production and sales. It is inferred that the transfer of technical information by means of the transfer of persons is especially active in the phases of application study, product development and production.

The active movement of persons is related to another characteristic of Japan, which is the emphasis on materialization in technological development (the process in which a technology is embodied in products, including software). A questionnaire of leading Japanese companies indicated a well-balanced allocation of engineers in the stages of research, development, and production. The process of transforming the germ of a new

technology and turning ideas into new products (or practical technologies) is nothing other than a series of trial-and-error approaches to troubles and problems. This process involves much creativity. For example, various techniques for the improvement of semiconductor production yields have been the result of research and development conducted in the production phase.

In Japan, many engineers engaged in development are actively involved in the academic presentation of their work and the patent application. Fig. 2-9 shows an international comparison of the percentage of researchers, engaged in either research or development, who published their work and the patent application. Unlike other countries, Japanese engineers engaged in development have as many opportunities to publish their works as those engaged in research. Contrary to the situation in other countries, more opportunities for patent application are given to Japanese engineers engaged in development than those engaged in research.

Seeing the importance of close feedback and placing emphasis on materialization, many Japanese companies allocate staff who have the necessary knowledge and skills to carry out the phases of technological development, as well as the phases of production and sales, in a well-balanced manner. The companies also attempt to ensure the fluidity of manpower allocation.

c) Diversification of Operation around Core Technologies

In the process of technological innovation, Japanese companies are seeking a shift toward diversified operation around core technologies. This tendency has been particularly remarkable in and after the 1980's (Fig. 2-10).

Industrial/scientific technology in the past had a strong tendency towards specialism. Each technology was usually applicable to only one field. However, as a result of these technological development and the maturation of industries, various types of technologies have become closely related. Now, new products are often created by combining different types of technologies which originally belonged to specific industries and by incorporating elemental parts of products from different fields.

Many companies are diversifying operations around core technologies which they have developed in their main field of business. As a result, they are expanding their

operation into various fields which seem unrelated to their main business. In response to an increase in the number of companies conducting such diversification, many are engaged in the strategic development and acquisition of technologies which are considered important for the future expansion of business.

Fig. 2-11 illustrates the case of clock technology. The application of clock technology to different fields was limited when clocks were driven by springs (mechanical clocks). However, exploration of new technological options enabled the incorporation of quartz oscillation, liquid crystal, integrated circuit (IC), and others to give rise to such things as quartz digital clocks (electronic clocks). As a result, clocks are now used in combination with other electronic parts, and the possibility of their application in other fields has increased remarkably. They are now used widely both for consumer and industrial use. Moreover, the clock industry has further developed semiconductor and liquid crystal technologies, so that the companies can expand their business into different fields other than clocks.

Similarly, plastics and semiconductor designing technologies are forming the basis for entrance into the IC card market, interface and polymer chemistry for entrance to the electronic industry, and oil prospecting projects are providing the core of the development into instrumentation business. Many other examples can be given.

Such a company or a group of companies realizing diversified operation around the axis of technology can be called a "technology complex," as opposed to the diversification through merging of capital.

What is common among companies which are diversifying operation through technology complexes is the flexibility to accept new technologies supported by sufficient technological power allowing the application of their own technology to other fields. To have such technological power, companies have to develop and utilize a group of high-quality engineers.

For example, recent advancements by steel companies in software have been supported by strong groups of software engineers working for a long time in the process control of blast furnace and rolling mill systems.

Subsection 2 Global Interdependence and Mutual Complementation of Technology

(1) Global Interdependence and Mutual Complementation of Technology

Technological innovation is a series of interactions cutting across national boundaries, in which various technological elements are incorporated dynamically. In most cases, the development of a practical product or technology involves the gradual accumulation of inventions and improvement realized in more than one country. For example, DRAMs (Dynamic Random Access Memories) have been realized through the development of various elemental technologies conducted by several companies in Japan and the U.S. Technological cooperation was and is promoted internationally in this situation.

Fig. 2-12 illustrates cooperation in the automobile industry. It shows that technological cooperation extends across national boundaries. In the semiconductor industry, as shown in Fig. 2-13, international cooperation has been increasing rapidly. Fig. 2-14 shows an extensive increase in the amount of technological trade since 1985. This increase also reflects the expansion of the global interdependence and mutual complementation of technology.

With the diversification of the processes of technological innovation, such interdependence and mutual complementation have evolved in many ways across the industry boundaries. Fig. 2-15 depicts the idea that progress in one industry assists progress in other industries. In particular, new materials, electronics, and information processing are attracting much attention from many industries. Such expectations will further expand the interdependence among industries.

Similar interdependence and mutual complementation are evolving in research and development activities. A questionnaire for Japanese researchers looked into how the development in various fields of technology is considered to be important in the pursuit of their own studies (Fig. 2-16). Results indicate that the development of information and software technology is especially important for the progress of research and development in other fields.

As outlined above, industrial and scientific technological activities are developed across industrial and national borders. Whether a company intends to develop and produce a product or whether a country intends to reinforce a field of industry, it will be increasingly difficult, both technologically and economically, to develop and own industrial/scientific technology in an independent and exclusive manner.

In response, companies have become increasingly dependent on other companies for the development and provision of elemental technologies and parts. Even among companies whose final products compete with each other in the market, it is often the case that the reduction of risk and the improvement of economic efficiency are pursued by means of cooperation in research and development, as well as the production of parts.

(2) Globalization of Business Activities and Industrial/Scientific Technology

Currently, many Japanese companies are trying to achieve overseas expansion of all or a part of their activities in management, business strategy, market development, research and development, production, sales, personnel management, financing, and procurement of materials.

Such globalization of business activities is deepening the interdependence of industrial/scientific technology across national borders.

The globalization of Japanese companies has been promoted rapidly in recent years, exhibiting some difference to that in Western and other Asian countries. A survey of Japanese companies reveals this difference (Fig. 2-17). In Western countries, the focus of globalization has moved from sales to production, R&D, and then to regional management headquarters. Full-fledged globalization has been promoted since 1985, involving the departments of research and development, as well as management. In Asia, production and sales sites have been established actively since the 1960's. At present, there are few areas of R&D sites.

World-wide, important changes occurred in 1955, 1970, and 1985. These years, respectively, correspond to the beginning of full-scale direct Japanese investment in foreign countries, the change of direction due to the stabilization of the high growth of the Japanese economy and the oil crisis, and the readjustment of exchange rates due to the Plaza Accord in 1985.

To facilitate R&D for the quick detection of the sources of technology and the prompt marketing of goods that meet local needs, companies are accelerating the overseas deployment of the bases for research and development.

The content of R&D activities in the early stages of the globalization of Japanese companies was limited to market research and marketing support functions in countries where they planned to expand. These activities have gradually extended to include the development of products that meet the needs of the new markets. Recently, research and development departments of companies are conducting overseas expansion on their own, apart from the activities of their sales departments. Basic studies are being activated at these research centers.

While the overseas expansion of Japanese companies is increasing, foreign companies are also actively conducting research and development activities in Japan. Fig. 2-18 shows the advancement of foreign investment in Japan. A remarkable increase has been seen in the number of research centers established in Japan by foreign companies.

The globalization of business activities including the establishment of research and development centers is motivated not only by economies of scale but also the advantages of complementary partnership. When various technologies, products and materials should be integrated into a product in a manner reflecting the characteristics of the market and technology, then a complementary partnership in technical aspects including the procurement of parts and materials, R&D and production are useful in reducing the risk of cooperating companies and in improving economic efficiency.

The globalization of business activities stimulates the globalization of scientific and technological activities, and thus contributes to the promotion of technology transfer. Technology transfer is being conducted in various forms including the trade of the actual technology, the transfer of production facilities (direct investment), the trade of products, technical assistance, etc.

However, there are a number of obstacles to technological transfer. In the case of direct investment, which is considered to play a central role in the technology transfer that accompanies globalization of business activities, obstacles in developed countries include differences in the protection of intellectual property rights, the underdevelopment

of peripheral industries (in countries having a small national economy), the resistance to mechanization and automation due to trade unions and local content regulation on direct investment. In the case of technology transfer to developing countries, recognized problems include the underdevelopment of the protection of intellectual property rights, the mismatching of transferred technology, the shortage of human resources and the lack of funds.

(3) International Exchange of Persons in Science and Technology

The international exchange of researchers and engineers has expanded with the enhancement of the global interdependence of industrial/scientific technology. As shown in Fig. 2-19, both the number of researchers and engineers sent to and accepted from foreign countries have been showing a steady increase. In fiscal 1990, the number of researchers accepted equaled that of those sent out. In comparison with the statistics from immigration control, however, the data indicate a much smaller difference between the numbers of researchers accepted and sent out, because the number of people who are engaged in public sector is not included. In addition the statistics of immigration control include a considerable overestimation of the number of Japanese researchers sent to foreign countries, because the data includes the attendance at academic meetings, short-term homestays, language training and other types of visits which are not related to the substantial exchange of scientific study.

Subsection 3 Diversity of Technology in Individual Industries and the Actual State of Technological Interdependence and Mutual Complementation

(1) Understanding of the Multilateral Nature of Industrial/Scientific Technology

Future development of economic activities and policies on industrial/scientific technology must be planned on the basis of the proper understanding of the present state of industrial/scientific technology. Because of the diversification, interaction, and global interdependence of technology, it is necessary to understand a sufficiently wide range of technology covering a substantial part of the market, taking into consideration the connection with other technologies both in and outside a nation. Furthermore, industrial/scientific technology should be regarded as a diversified accumulation of technologies, including not only technologies embodied in products but also the

technologies for producing the product with high precision and high efficiency, the accumulation of the results of research and development which provide the background for new technologies and products, and the experience and know-how accumulation. It is also important to know what element of technology depends on which person and in what form.

Given this, it is necessary to conduct a multi-lateral analysis highlighting various elements involved in industrial/scientific technology, rather than a technical comparison of a certain high technology from a specific aspect.

For example, industrial/scientific technology cannot be understood adequately by comparing the performance of products born by high-tech industries. Many so-called lowtech products incorporate high technology in their development and production, as well as materials. The technology to improve the yield of production is also an important aspect of industrial/ scientific technology.

(2) Actual State and Trends of Industrial/Scientific Technology in 16 Important Areas of Industry

Based on the discussion above, an analysis was conducted to identify the trends and characteristics of industrial/scientific technology. Both for Japan and the U.S., 16 industries having the largest sales were selected for study. From these industries, 22 products having the largest sales were selected. These 16 industries represent about 92% of the sales of all industries combined in Japan and the U.S. and include a wide range of industries.

This survey clarified several important factors that influence industrial/scientific technology.

First, the increasing demands of users is an important motivation for active technological development in all phases from the production of materials to the processing of final products. The requests for products are high at all stages of business activities: the end users, the manufacturers of final products using intermediate products and parts and the users of materials. This represents an important factor for the improvement of industrial/scientific technology in Japan.

Second, the interdependence of technology has made it necessary for an industry to establish technical superiority through utilization of technological power of a wide range of related industries. For example, the automobile industry needs technical support from the suppliers of steel, nonferrous metals, other materials, electronic and plastic parts as well as the support from robot makers in the automation of assembly plants.

Market needs, market size, and the industrial structure are additional factors characterizing the industrial/scientific technology of a country. The fact that aluminum rolling plants in the U.S. are equipped with high-efficiency mills is a reflection of the size of the American market for aluminum cans, which is 10 times as large as that in Japan. The specialization and differentiation of printing companies according to the type of printed matter enable the use of different resolutions in the printing process.

Subsection 4 Actual State of Basic Research in Japan

(1) International Contribution of Japan to Industrial/Scientific Technology

Japan has rapidly activated its efforts in industrial/scientific technology in parallel to it's economic growth. The total investment in research and development has reached the highest level in the world, i.e., 2.99% of the GNP (1990).

About 20% of patent applications in the U.S. and about 15% of that in Europe are submitted by Japanese applicants. Indeed, the technological power of Japan is greatly recognized in the world.

However, the contribution of Japan to the advancement of science has not always been sufficient. Fig. 2-20 compares GNP, the investment in research and development, the technostock of science accumulation type, the number of academic papers published, and the number of foreign patent applications between 5 countries: Japan, the U.S., the U.K., Germany, and France. Relation to its GNP, Japan's contribution has been very small in terms of the technostock of the science accumulation type, which is an index for activities in basic studies and the number of academic papers published.

(2) Actual State of Research and Development Activities in Japan

The contribution of private companies to research and development in Japan is examined on the basis of expenditures illustrated in Fig. 2-21. The share of private companies in the costs of R&D has been increasing steadily and has exceeded 80%. This is considerably larger than other developed countries. When examined based on the execution of R&D projects. the share of industry, universities. and governmental laboratories are 80%. 12%. and 8%. respectively. It is clear that industry is leading the research and development activities in Japan.

For this reason, as much as 60% of research expenditure in Japan is devoted to development studies (Fig. 2-22).Application studies and basic studies represent only 24% and less than 13%. respectively. Although the yen value of the costs for basic studies has been increasing steadily, those for application studies and development studies have been growing even more rapidly, and the share of basic studies is still showing a decreasing tendency.

Researchers in the industrial environment in Japan have excellent equipment and ample per-capita research budget. and it is internationally recognized that they conduct high-level R&D. On the other hand, the research environments of universities and public organizations generally involves many problems. With few exceptions, the level of study is not highly regarded.

In this situation, there are expectations for industry as the sponsor of basic studies. Statistics show that the proportion of basic studies in the research and development activities of companies has been increasing. At present, the share is 6.5%. The share of private companies in all basic studies in Japan has reached 40%. However. basic studies conducted by companies are usually different in nature from those conducted at universities and national laboratories.

(3) Actual State of Basic Research in Companies

As a result of the enhanced interaction between science and technology. companies have come to conduct more basic and fundamental studies.

However, as shown in Fig. 2-23, basic studies in companies are different form those in universities and national laboratories in that some contribution to the company's business is expected. A detailed analysis of the R&D expenditures of a company revealed that studies which correspond to the basic studies conducted at universities took 1% of expenditures.

Another issue with basic studies in companies is the lack of public access. When an outsider attempts to access the results of R&D, it is generally true in all countries, that access to the activities at universities is more easily attained than activities at companies because of the close connection with product development strategies and intellectual properties. For this reason, the fact that industry has a large share of R&D activities in Japan tends to incur criticism that the access to Japanese scientific and technological information is more limited, compared with other developed countries.

Fig. 2-24 shows the share of researchers belonging to companies responsible for academic papers published between 1974 and 1990. In this survey, a "paper" has been counted as conducted by a company, if any of its co-authors belonged to a company. The ratio of company researchers publishing a paper is extremely small in comparison with the amount of expenditure for basic studies.

A basic study is, in its original sense, a study concerning very fundamental findings which can be published in the form of an academic paper. The scarcity of papers written by corporate researchers may be attributed to two reasons. First, companies may not be sponsoring many basic studies which can be published in the form of scientific studies, as is expected from the high ratio of expenditures for basic studies. Second, companies may not be eager to publish the results of basic studies, even if they deserve publication.

(4) Areas of Research and Development in Japan

Fig. 2-25 summarizes the results of a questionnaire on the areas of R&D sent to approximately 800 researchers in Japan. It evaluated the areas of research and development in Japan from 5 aspects: research facilities, the number of researchers, the quality of researchers, quantity of results produced and the quality of the results. The findings were compared with Europe and the U.S. As shown in the figure, the environment of research and development in Japan is inferior to that in both Europe and the U.S. in all fields of technology, except for communication and electronics.

(5) Need for Increased Government Investment in Research and Development

Because of the situation discussed above, a drastic increase in government investment in R&D is considered necessary to promote the accumulation of international public assets, including the results of basic studies.

As of 1992, technostock of the non Commercially Oriented R&D which arose from government investment in R&D is about 5 times smaller than that in the U.S. If government investment was increased immediately, the amount of technostock would begin to increase only after a further 8 years, because it would take time to obtain the results from the studies. If the investment were kept at the increased level, it would take about 25 years until a sufficient effect is observed (Fig. 2-26). Therefore, a increase in R&D investment is an urgent issue.

Section 3 Changing Situations in Industrial/Scientific Technology

Subsection 1 Changes in the Expectations for Industrial/Scientific Technology and the Problem of Manpower

(1) Changes in the Expectations for Industrial/Scientific Technology

Past industrial/scientific technology, R&D was chiefly focused on the efficiency of production and services and the improvement of economic performance. In this manner, technology has contributed greatly to the development of economic and industrial activities and the prosperity of mankind. However, environmental issues, population growth, shortage of energy resources, and other problems have emerged on a global scale. At present, the solution to these problems is an issue of common priority for all people. With the limits in the capacity of planet earth becoming apparent after the rapid expansion of human activities, we are now required to develop technologies which are environmentally sound, such as production techniques that pose little load on the earth's capacity and techniques for the conservation of resources and energy.

The advancement of science and technology has improved the labor conditions and other activities of people. It has improved health conditions and eliminated heavy

physical labor. However, because of economic reasons, simple monotonous labor and physical labor are still required of people on many occasions. In the present age when the pursuit of affluence and choice are desired, we are required to develop technologies for the realization of living and labor conditions where humankind can pursue a quality lifestyle.

In this context, expectations of industrial/scientific technology are changing. A survey was conducted on the urgency of the themes of development in industrial/scientific technology which should be promoted by the government. The results indicate that many Japanese people recognize the urgency of problems such as the solution of global issues including global environmental issues and the issues of resources and energy. They also recognize the urgency of the assistance to elderly and disabled people, as well as the improvement of social services including medical services and the improvement of health (Figs. 3-1 and 3-2).

Such changes in the perception of people are reflected in the perception of companies. A questionnaire indicates that more than 60% of Japanese companies are conducting research and technological developments concerning environmental protection (Fig. 3-3). The percentage of environment-related investment in all R&D expenditures increased from about 9% in 1985 to about 13% in 1990. However, there are major obstacles to addressing CO2 emissions and other technological innovations, due to technical difficulties, the large scale of development investment, and the uncertainty about the recovery of investment.

Many people feel concern about the direction of science and technology. The effort to remove this anxiety should be an important element in the future development of science and technology. A survey by the Prime Minister's Office revealed that about 58% of people feel that the advancement of science and technology is too rapid, and about 77% of people think that the danger of abuse and misuse of science and technology is going to increase (Fig. 3-4).

(2) Supply and Demand for Researchers and Engineers

The recruiting and the effective allocation of high-quality researchers and engineers is extremely important for sustainable development of industrial/scientific technology. With the spread of advanced technology, demand for researchers and

engineers is high in not only manufacturing but also service industries. However, expansion potential of educational institutions training researchers and engineers are limited. As shown in Fig. 3-5, the demand for trained specialists outstrips the supply. The international tendency for young people not to choose scientific careers and the expected decrease in the number of young people in Japan threaten to cause a severe shortage of researchers and engineers.

The efficient allocation of high-quality researchers and engineers is an important element for the full utilization of valuable human resources. However, the result of recruiting graduates as of February 1992 (Fig. 3-6) reveals the centralization of recruits in large companies and the difficulty of recruiting for small firms. There is a fear that the uneven distribution of human resources may result in the wasteful use of them, leading to stagnation of technological activities. It may aggravate the shortage of engineers and the inactivation of technological activities.

However, these problems are not limited to Japan. Therefore, the invitation and employment of engineers from foreign countries should be conducted with sufficient care so that there should not be a misunderstanding that Japan will somehow solve the shortage of engineers by employing foreign engineers.

Subsection 2 Development of Policies on Industrial/Scientific Technology

(1) History of Japanese and U.S. Policies Related to the Development of Industrial/Scientific Technology

Policies on industrial/scientific technology have been developed along different courses in Japan and in the U.S., reflecting the history and the system of each country.

Japan first placed emphasis on the introduction of technologies during the implementation of economic recovery policies after the world war II. Later, with the liberalization of capital and trade, R&D was promoted in cooperation with industry, academia and government. The aim of these efforts was to eliminate excessive dependence on imported technology and to enhance Japan's power in industrial technology, whilst keeping a balance in imported technologies. This R&D was focused on energy-related technology, material technology, process technology, control technology, and electronic technology, all of which were considered to play central roles in industrial

activities. The government took part in the fields of R&D which was considered essential for improvement of the national economy but was too risky to be conducted by the private sector. Cooperation among industry, academia, and government was constructed so that the limited resources for R&D could be fully utilized.

Past government-assisted R&D had a strong bias toward application projects. With the improvement of R&D capabilities in the private sector, the focus of such R&D has been shifting to more basic and fundamental fields of study. In response to recent developments in the globalization of industrial/scientific technology, the government has been promoting open access for overseas researchers to governmental research and development projects (no discrimination across borders) with the purpose of facilitating the international distribution and transfer of science and technology. Furthermore, international study cooperation is promoted actively.

Turning to the U.S., the post-war policies on technology were premised on the desire to assist R&D in the fields of national security, space exploration, and the security of energy, all of which had important roles in the national mission of the country. Emphasis was also placed on basic studies, where the market principle would not ensure sufficient investment. Improvement in the level of industrial technology was expected to occur through indirect effects such as the spin-offs from mission studies and the application of the results of basic studies.

With the growth of interest in industrial competitiveness, however, the improvement of the technological level of industry was clearly recognized in U.S. national policies in the mid 1980's. As exemplified by SEMAT, a consortium for semiconductor studies, R&D in the private sector was supported with more direct measures. In 1990, the Advanced Technology Program (ATP) was initiated as a program to assist R&D in the private sector with the purpose of increasing industrial competitiveness. This program has been further expanded and enriched. Because these programs are chiefly aimed at the enhancement of the competitiveness of American industry, the access from other countries is either limited or operated on a mutual basis.

As outlined above, course of policies in Japan and the U.S. seem to be flowing in opposite direction. At present, however, they have a general common purpose of assisting R&D in the fields of technology where considerable difficulty exists and market incentives will not ensure smooth advancement. This phenomenon is in the direction

discussed at international forums on technology policies. However, there are differences between Japan and the U.S. concerning the specific field of R&D, the forms of government assistance and the overseas access to government-assisted R&D programs. It is expected that further discussions will be taken up at future international conferences.

(2) Changes in International Attention to Policies on Industrial/Scientific Technology

The focus of discussion on science and technology policies has been under transition (Table 3-1). The focus of interest of OECD, for example, was the issues concerning R&D in the 1960's. In the early 1970's, the focus was shifted to the technology gap between nations and discussions were held concerning the form of international cooperation and the international distribution of scientific and technological information to eliminate such a gap. In the mid 1970's, with the growth of the awareness of the limitation of energy and resources and global environmental issues, cooperation and technological assessment in fields related to energy and environmental became part of the agenda. In the 1980's, it was recognized that economic growth and other related aims were not attainable by simply promoting R&D. The promotion of innovation became the focus of political interest. In the late 1980's, globalization of scientific and technological activities was recognized strongly and the nature of basic studies as an international public asset was acknowledged. A consensus was reached that every country should make a well-balanced contribution to the creation of such an assets. Much attention was directed to the problem of international coherence of policies concerning scientific and technological activities. The problem of protection of intellectual property rights, for example, was discussed at WIPO (World Intellectual Property Organization) and on other occasions. In addition to intellectual property rights, the problems concerning industry subsidies including the assistance of R&D, are now being discussed actively at GATT (General Agreement on Tariffs and Trade) and other occasions.

In recent years, it is strongly recognized that the development of scientific and technological activities are influenced by various factors including economy, education, labor and regulation. The OECD, in 1988, began the work of comprehensively examining science and technology from various aspects such as economic and social activities. A policy statement based on the results of these discussions was submitted to the Ministerial Board in 1991 ("A Policy Statement on Technology and Economy": Fig. 3-7). This policy statement declared that the basic responsibility of a government lies in the improvement of the environment for technological development. It also stated that

measures of assistance aimed at the promotion of a specific industry or a field of technology are economically inefficient and can cause international friction. To provide a desirable environment, it was considered necessary to ensure consistency between various policies concerning the macro and micro economies, improvement of social capital, education and employment, regulation, etc. The statement referred to the possibility that, because of global interdependence, international friction can occur if different countries pursue different policies reflecting their characteristic system of technological innovation. It proposed a discussion concerning the need for international coherence between related policies.

This movement intending to augment the understanding of the processes of technological innovation and to reflect it in science and technology policies has been seen not only in OECD but also on various occasions in formal and informal international discussions.

For example, Japan and the U.S. agreed to conduct a joint study on "technology transfer" in October 1991, based on U.S.-Japan Science and Technology Cooperation Agreement. The term "technology transfer" refers to the process in which a germ of technology born at a university or government laboratory is evolved towards commercialization. In effect, this is nothing other than the process of technological innovation and popularization. Japan is weak in basic studies, but quick in commercialization. On the other hand, the U.S. has outstanding science and technology, but has problems in commercial utilization. Each has a characteristic system of technical innovation and popularization. The joint study was commenced with the recognition that each country has something to learn from the other.

As a basis for such examination, it is necessary to have a correct understanding of the actual state of industrial/scientific technology and to share it on an international basis. To this end, OECD plans to conduct a study to elucidate the realities of the situation and to examine the political significance and the need for any new "rules of the game."

International "rules of the game" concerning scientific and technological activities have already been examined in various fields. For example, the protection of intellectual property rights was a focus of the discussion at WIPO. Aiming at international rule-making, specialist-level discussions were held concerning the extent of patents, the

unification of the period of patents, the unification to the prior application principle and the limitation of the time required for examination. In particular, the U.S. is pressed for the unification with the prior application principle, which is commonly regarded as a prerequisite for a patent reconciliation treaty. On the other hand, Japan pressed for an adjustment concerning the limitation of time required for examination. WIPO is also discussing a treaty for the reconciliation of trademarks and a treaty to establish a mechanism for the solution of international disputes.

Similarly, GATT has taken up the problem of intellectual property rights from the aspect of trade, as it affects the industrial competitiveness and international trade. TRIP (Trade Aspect of Intellectual Property Rights) negotiations are ongoing in the GATT Uruguay round with the purpose of eliminating the differences in the standards and methods of the protection of intellectual property rights among developed countries, as well as to eliminate legislative measures in developing countries which discourage foreign companies and protect domestic industry. As a result, a draft agreement of TRIP was presented at the end of 1991. The draft agreement includes the obligation to protect substance patents, the specification of the period of patent protection, international protection of trademarks and designs, and other provisions covering the whole range of issues concerning intellectual property rights.

International rule-making to protect the fruits of science and technology is especially important in the present era, where products and technologies are distributed on a global basis.

OECD has been working on the safety of recombinant DNA technology used in industrial activities. This effort is an example of a process in which international standards intended to facilitate safe and smooth popularization of a new technology were formulated by building a common international understanding of the technology and of the problems stemming from it and by attempting to make international adjustments from the responses of different countries.

International standardization is the effort to define international standards of technical terms, methods of tests and evaluation, specifications for techniques and products, etc., though the adoption of the international standards is voluntary in principle. The improvement of the interchangeability and compatibility of parts, components, and technical data is expected to facilitate the interaction of scientific and

technological activities conducted at various places. This also is a form of the defining the international "rules of the game."

Efforts for international standardization are chiefly promoted by the International Standardization Organization (ISO), International Electrotechnical Commission (IEC), and International Telecommunication Union (ITU). A prerequisite for the smooth promotion of international standardization is that the leaders in technical fields should actively provide technical information and take a positive role in the adjustment of differences among nations. Japan is expected to make a contribution proportional to its outstanding performance in industrial/scientific technology. Up until this present time, however, Japan has taken a modest leadership role.

Chapter III Comprehensive Evaluation — Significance of Policies on Industrial/Scientific Technology

Section 1 Evaluation of the Present State of Industrial/Scientific Technology

Subsection 1 Comprehensive Perception

(1) Diversity of Technological Innovation Processes and the Growth of Global Interdependence and Mutual Complementation

The process by which a new technology takes root and develops to commercial applications cannot be explained by a linear, one-way flow from a new scientific finding to application study and development. It requires repeated searches for a matching combination between market needs and corresponding technology seeds at various phases of research and development. In other words, frequent feedback in the various processes of research and development enables the development of a technology which satisfies market needs. Therefore, the key to the success of commercialization is the accurate understanding of market needs and the research and development efforts to realize the products or services corresponding to the needs. It is not the case that the germ of technology (seed) leads to commercialization by itself.

Combination and fusion of scientific and technological knowledge in different fields are promoted as an approach to the creation of new technologies. Increase in the diversity of market needs and that of scientific and technological activities are expanding the potential profitability of such combinations and fusions. At the same time, it has become difficult for the sponsor of a technological development to create the whole set of necessary technologies singly. Thus, diversification has become an important factor promoting cooperation and collaboration among different organizations conducting the developments. As scientific and technological activities are expanded across national borders such interdependence has also developed internationally. Interdependence is reflected in the globalization of business activities such as the increased international exchange of researchers, international business cooperation, and direct overseas investment, as well as in the increase in technology trade.

Each country has its own characteristic process of technical innovation, which reflects the economic environment, market needs, the system of research and development, scientific and technological human resources, and other domestic factors. This has also been confirmed in a survey based on the fields of industry. The diversity of the process of technological innovation among countries, along with international interdependence and mutual Complementation, is expanding the potential benefit. In this case, the contribution expected from each country should differ according to the reality of industrial/scientific technology in each country and according to changing circumstances.

Much emphasis has been placed on basic studies, which were considered to create new scientific knowledge and lead to the birth of innovative technologies. In the present deepening interaction between science and technology is, where the progress of science is accelerating the development of industry, and the development of industry is stimulating the progress of science, companies are increasingly engaged in more basic studies in their efforts for research and development. However, all new technologies are not induced by new scientific findings. It is clear that the development of products meeting market needs is the key to the commercialization of new technologies.

Basic studies play an important role in the process of technological innovation because they expand the wideranging base of scientific knowledge shared by the world and they are applied to R&D activities not only in the initial phase but also the whole process of R&D.

(2) Approach to Mankind's Common Problems and the Creation of Scientific and Technological Knowledge as a Common Asset of Mankind

The importance of science and technology issues common to the whole world is increasing and more and more of these activities are demanding international cooperation and coordination.

The problems of acid rain, global warming, deprivation of natural resources and other problems common to the whole world, for example, demand the development of technologies which are environmentally sound, such as technologies that consume fewer resources and less energy and those preventing pollution. It is also necessary to develop

technologies which are beneficial to people, such as the improvement of health and medical services, the improvement of living and labor conditions, etc.

The solution to these technological issues may not be promoted smoothly if efforts are solely based on market principles which pursue economic efficiency.

Basic studies are regarded as a common asset of the whole world, as discussed above. Each country is expected to make a reasonable contribution to this asset commensurate with the economic and technological power. The knowledge base of the whole world can be expanded, both quantitatively and qualitatively, through the promotion of original basic studies conducted in each country utilizing its distinct features. Similarly, the accumulation and standardization of scientific and technical data, which are shared by the whole world and comprise the software infrastructure of scientific and technological activities, play an important role in the promotion of scientific and technological activities globally.

There are study themes which are expected to contribute to the formation of the basis for science and technology shared by the world, but are too costly to be conducted by any one nation. Examples of such themes are projects requiring extremely costly facilities, such as the construction of giant particle accelerators used for the study of basic physical phenomena and projects requiring global coordination of research activities conducted at many locations around the world, such as the analysis of the human genome or studies on the global environment.

To develop science and technology and to utilize these developments in various industrial activities, there must be adequately trained personnel. Whilst the demand for such persons is increasing on a global basis, their training is far behind the demand. The development of human resources is one of the important global issues.

Finally, the fact that international expansion of industrial/scientific technology activities is deepening global interdependence, and the increased importance of global issues that should be addressed through global cooperation, there is an increasing need for the examination of related policies from an international standpoint.

Subsection 2 Perception of Specific Issues

(1) Creativity of Technological Development in Japan

Japan has an outstanding ability to utilize the fruits of science and technology, created both in and outside the country, in the production of goods meeting market needs. With this ability, Japan has been developing an internationally-recognized high levels technology. As a result, Japan occupies 15% of the world's economy and has become the second largest economic power behind the U.S. As background to this growth, there has been active R&D activities conducted by the private sector, which now occupies 80% of all R&D expenditures in the country and two-thirds of human resources in the field of science and technology. While Japan is adept at a gradual approach, in which imported novel technologies and ideas are improved, this nation is regarded as weak in original technologies. Certainly, Japan has fewer examples of innovative technologies than Western countries. In this respect, Japan is regarded as failing in sending out original technologies to the world, despite the reputed superiority in industrial/scientific technology. The balance of technology trade with developed countries has been marked by a large surplus for years.

However, as analyzed in the previous chapter, the key to the development of new technologies and new products is the process in which market needs are detected correctly and feedback to the realization of products, whilst promoting the fusion and diversification of various technologies. This process includes various technologies such as product development, production technologies, management of research and development and market research and thus the process is an extremely creative activity in itself. Creation in such activities, however, is not adequately appreciated in the world. One of the reasons may be that Japan has not been actively demonstrating the real picture of Japanese technology to the world. (This is also a reason for the alienation of citizens from science and technology and a reason why young people do not choose engineering as a career.) Another reason may be the immaturity of international understanding of the reality of industrial/scientific technology and the technological innovation process.

(2) Need for the Enrichment of Basic Research in Japan

In the field of "science," Japan is not as highly regarded as other developed countries. Universities and government research organizations, which are central players

in basic studies, are suffering from the problems of restrained budgets and inflexible systems of personnel exchange, which are restricting research activities. Although a few outstanding scientists have recently appeared in Japan and some improvement was made to fill the gap in personnel exchange with other developed countries, the number of researchers sent to other developed countries is still exceeding the number of those spent to Japan. The amount of technostock of the science accumulation is still considerably smaller than that of the U.S. In terms of the scale of R&D investment, the gap between "science" and "technology" is expanding. In particular, the needy circumstances of universities and governmental laboratories may impair the training of future human resources not only in basic studies but also in science and technology. In view of the construction of an international knowledge base, it is difficult to say that Japan is making a contribution proportional to its economic and technological power.

(3) Need for Techno-globalism

As discussed above, scientific and technological activities are being developed in diversified ways which reflect the environment of each country. Inherent to the relationship between these activities is its potential synergistic effects. There is a possibility that this interaction may stimulate the development of science and technology, further enhancing the benefit brought to humankind. In other words, the interaction between diversified scientific and technological activities produces a positive cumulative effect that assists humankind. It is desired for each country to promote the foundations of science and technology and to facilitate the international distribution and transfer of the fruits of its creation (i.e., the promotion of technoglobalism).

(4) Changes in Requests to Industrial/Scientific Technology

The manifestation of global environmental issues and the desire of people for true wealth are pressing us for changes from the past system of technology, which gave priority to productivity, efficiency and economic performance. There is a great need for future technologies which are humanistically and environmentally sound such as production technologies posing little environmental load, technologies to conserve resources and energy and technologies affording truly affluent labor and living conditions.

Section 2 Directions of Response

Subsection 1 Promotion of Techno-globalism

If an imbalance occurs between countries in terms of their contribution to the creation of science and technology or to the enjoyment of the benefits of science and technology, it can be a potential cause of international friction. If a country is much too interested in its industrial competitiveness, it can induce exclusive pressure on the assistance given to scientific and technological activities or the access available to other countries. As a result, the international distribution and transfer of science and technology can be impaired and benefit to the whole world may be reduced considerably.

To avoid such negative tendencies and to secure an environment for autonomous exchange of science and technology where each country willingly participates each country must bear the appropriate responsibility in its science and technological research base. This will facilitate active transfer and exchange of technology so that there will not be considerable differences between benefits obtained by different countries. Furthermore, countries must endeavor to establish an international order where technological innovation and its popularization will be promoted effectively and efficiently all over the world. In this regard, Japan must take an initiative proportional to its economic and industrial/scientific technological power.

(1) Creation of Original Scientific and Technological Knowledge and Establishment of a Basis for Scientific and Technological Activities

In relation to the generation of science and technology, basic studies are the source of the knowledge which is utilized in a wide range of activities. The results of these studies become a common asset of the world. Because the market principle may not ensure sufficient investment, however, it has been confirmed on several occasions including in the "OECD Technology and Economy Program" that the government should actively support basic studies. In this situation, Japan is generally regarded as "being weak in basic studies and failing to make international contribution proportional to its economic power," incurring the criticism of the so-called "free-ride". For this reason, Japan must make efforts to contribute original scientific and technological knowledge and to enrich the basis for it.

Firstly, to be able to advocate techno-globalism to the world, Japan should strengthen domestic basic studies, break away from the mentality of catching up to other countries and strive to send out results of creative studies that can lead to new concepts or breakthroughs. In this process, as remarked by OECD, basic studies should not be isolated from the increasingly enhanced interaction between science and technology and cooperation between the public and the private sectors should be promoted. Japan is requested to make a contribution, proportional to its economic and technological power, to the creation of a stock of general scientific and technological information, as well as the provision of a data base for it. This would serve as the infrastructure of the scientific and technological activities of the world, including the base studies.

Secondly, looking at the exploration of a scientific frontier, Japan should take a lead in the challenge of R&D in original fields of research, as well as mega science, to contribute to the expansion of the global basis for science and technology. Sinee mega science cannot be promoted without the concentration of enormous scientific and technological resources from many countries, it is a field where the contribution of Japan is expected.

Thirdly, when the frontiers of scientific and technological studies are explored to obtain more sophisticated expertise and more diversified knowledge, an appropriate balance should be ensured between competition and cooperation to facilitate efficient promotion of R&D corresponding to market needs, which are increasingly diversified. In this respect, an effective means to improve the efficiency of research should be the promotion of the collaboration on fundamental technologies in the pre-competition phase, while the research and development in the phase of product development (customization) should be promoted in a competitive environment. Needless to say, such collaboration, if conducted internationally, will also contribute to the materialization of the potential benefits of global interdependence.

Finally, human resources must be cultivated to develop science and technology and to promote its utilization. This problem must be addressed with the aim of not only eliminating the shortage of manpower in Japan, but the global shortage as well. For this purpose, education should be improved so that the interest in science and technology and the spirit of inquiry will be encouraged. It is also necessary to enhance the morale of people engaged in R&D by improving their work environment and by improving the

incentives. The abilities of valuable human resources in science and technology should be fully utilized and their wasteful use should be avoided.

It is therefore necessary for Japan as a whole to create a research environment in which basic, original studies are promoted on a permanent basis. An open, ideal environment which can produce studies deserving of high international recognition and which attracts excellent talent from all over the world, should be created at universities and national laboratories, in particular; but also at private institutions. In other words, an important goal is the creation of centers of excellence in diversified ways.

(2) Taking Active Roles to Send out Information, Provide Technology Transfers, and Promote International Cooperation

There is a need for the creation, transmission, and transfer of science and technology aiming at its international distribution. Furthermore, to ensure the well-balanced development of all countries in the world, each country must improve its R&D abilities so that it can benefit from science and technology. In this respect, developed countries must actively promote technology transfer, on the condition that developing countries endeavor in self help activities. Japan should promote international transfer of science and technology in the fields where Japan is leading the world and assist in industrial activities and the improvement of the research and development abilities of developing countries.

Firstly, it is necessary that Japan conveys to the world the actual state of science and technology in Japan. In this respect, it is desirable to conduct a scientific analysis of Japanese technologies which are highly evaluated and attracting attention, and transmit this to the world in a readily understandable form.

Secondly, it is necessary to promote the exchange of persons and stimulate the transmission of scientific and technological information, such as the publication of academic papers, as well as to improve the infrastructure, including data bases. The acceptance of researchers from other countries and the opportunities for foreign companies to conduct research and development in Japan should be increased, so that overseas access to Japanese R&D activi-ties may be enlarged.

Thirdly, Japan should actively promote technology transfer to developing countries and CIS states to enhance the research and development ability in these countries. In this process, the history of Japanese technological innovation may provide valuable examples. It is the responsibility of Japan as a developed country to summarize its experiences in a readily understandable form and transmit it to the world. This should include Japan's success of introducing foreign technologies, developing and elaborating them and then utilizing them in industry, as well as failures such as the generation of industrial pollution and the processes in overcoming it.

Finally, international study cooperation should be promoted actively, with the purpose of efficient creation and popularization of science and technology, making full use of the strength of each technology and promoting the effective utilization of the resources for scientific and technological activities.

(3) Creation of an International Order for the Distribution and Transfer of Technologies

With the international expansion of scientific and technological activities, the influence of science and technology policies of each country is exerted on other countries. If each country pursued the improvement of its own power and adopted nationalistic policies conflicting with the globalization of scientific and technological activities, it would result in inefficiency in the use of resources for these activities. It would not only reduce the potential benefit mankind can derive from science and technology but also may be a cause of international friction. It is necessary to avoid such situations and establish an international order where technological innovation and popularization may be promoted effectively worldwide.

For this purpose, every country should share the awareness of the problems and deepen the mutual understanding of the technological innovation systems available in each country. Based on this understanding, details of the rules of the game, such as the international reconciliation of the protection of intellectual property rights and that of patent systems should be promoted, keeping adequate communication open between countries in accordance with the actual state of science and technology in each.

In this respect, Japan is also expected to transmit the reality of Japanese technology clearly and to take adequate initiatives in the promotion of international reconciliation of policies related to science and technology.

Subsection 2 Toward the Construction of a Technological System Benign to People and Environment

Up until now, technological innovation has been supporting the prosperity of mankind by stimulating economic activity and promoting economic growth. From this, humankind became separated from the natural environment as the world became smaller. Environmental issues, energy resource issues, food problems and many other global issues have become apparent. Without a solution to these problems, our next generation may not be able to prosper.

If humankind is to survive within the reality of limited natural resources, it is necessary to create a new system of technology which is humanistically and environmentally sound, such as the technologies conserving resources and energy, as well as those imposing little load on the environment.

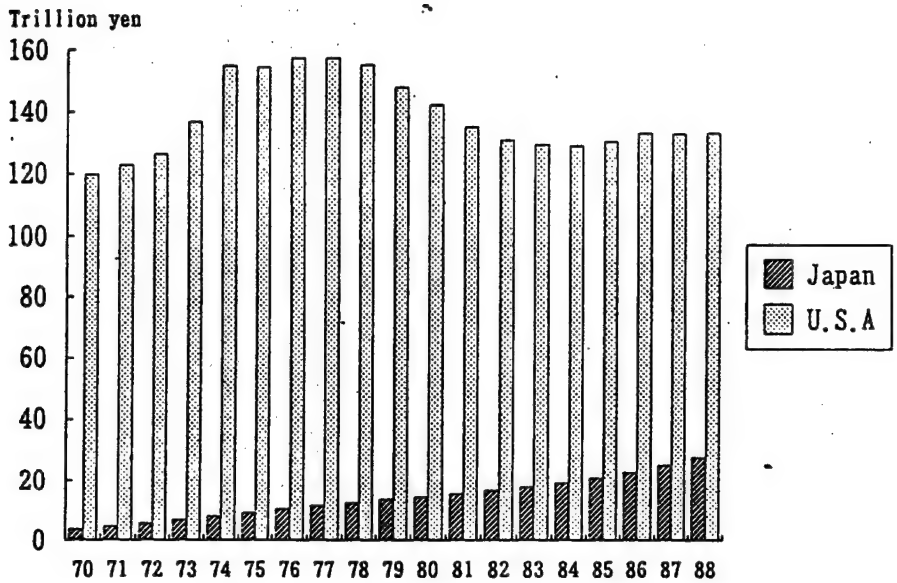
The progress of science and technology has been altering lifestyles. Such alterations have generally led to the improvement of the living and working environment, such as the improvement of housing environment and the elimination of heavy labor. However, simple work requiring intellectual ability and physical labor are often performed by people because of economic limitations. In the future, with the decrease in the younger segment of the population and the advancement of an aged society, the work force supply will became increasingly tight. It is necessary to develop technologies that can help create more civilized living conditions and a better work environment.

For the construction of such a system of technology; it is necessary to define the direction more clearly and specifically. It is also necessary to accumulate fundamental scientific and technological data, as well as to establish a scale of evaluation, which is used to make judgment on the introduction of a technology. Many themes are just beginning to be examined. Future developments are expected.

Finally, because of the rapidity of the advancement of science and technology, some people feel a sense of anxieties concerning science and technology or, in extreme cases, harboring anti-technology feelings. As a part of the efforts for smooth promotion of the spread of new technologies, attempts should be made to improve its acceptability to society through the provision of better technological assessment. The present picture and the history of science and technology should be transmitted to citizens clearly so that they may understand and have a positive and healthy feelings toward science and technology.

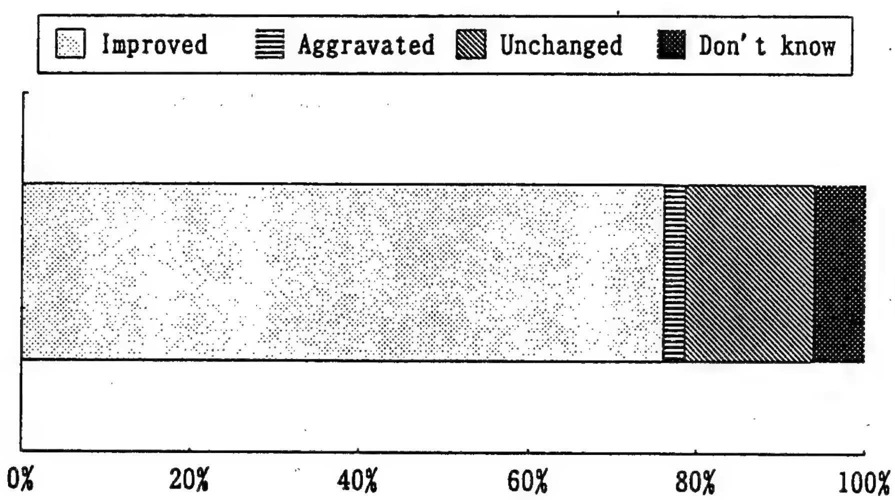
Figures and Tables

Fig.1-1 Changes in Japanese and U.S. Stock of Technological Knowledge (Commercially Oriented R&D)



Compiled by AIST.Technology Research and Information Division from "Research on the Quantitative Comparison of Technostock in Japan and the U.S."(Economics Research Institute.Japan Society for the Promotion of Machine Industry).[1992]

Fig.1-2 Do Science and Technology Improve the Standard of Living?



Prime Minister's Office."An Opinion Poll on Science and Technology and Society"(conducted in January, 1990).

Table 1-1 Representative Products and Events after World War II (Japan)

Year	Product	Consumption Trends	Economic & Social Events
1948	Adhesive tape		
1949	Electric washer (stirring type)		Exchange rate fixed at $1=¥360
1950			Outbreak of Korean War
1951	Synthetic detergent Air conditioner		
1952	Electric refrigerator Nylon stocking		Radio contracts exceed 10 million
1953	Black & white TV Vacuum cleaner Blender LP record	Fluorescent lamp and electric washer	NHK TV broadcasting begins in Tokyo
1955	Transistor radio Electric rice cooker		"3 status symbols"
1957	Electric "kotatsu" Contact lens		NHK FM broadcasting begins
1958	Japanese stereo record Boom of 8-mm projector Instant noodles Light weighted car		Kanmon Tunnel opened
1959	Ball-point pen Small car Electronic organ Half-size camera Instant coffee Food wrap	"My car" era	
1960	Transistor TV	Instant foods (noodles, coffee, etc.) in boom	The Income-Doubling Program introduced Regular broadcasting of color TV begins
1961		EE camera	
1962	Japanese electronic copier		NHK TV contracts exceed 10 million (48.5% of households)
1964	Transistor-type calculator		Tokaido Shinkansen Line opened Tokyo Olympic Games
1965	Microwave oven		"3C" era. Depression
1966	Color TV		
1967	TV telephone Mini calculator		
1968	Marketing of retort foods Radio cassette recorder		
1969	Cassette tape recorder	"Snack" foods	
1970	4-channel stereo Date recording camera	Vending machine and coin-operated rockers Fast family restaurant	International Exposition in Japan
1971		Fast food shop	Nixon shock
1972	Cup noodles	Home security business	
1973	Quartz watch, digital clock Electric rice cake maker Push-button home telephone	Imitation foods	First oil crisis
1974	Polaroid camera appear on the market Lunch jar		
1975	Solar heating panel VTR for home use	Price battle of calculators	
1976	Motor scooter Door-to-door parcel delivery		
1977	Auto-focus camera Bed pad dryer		First Micro Computer Show
1978	Digital/analog watch Japanese word processor		Second oil crisis
1979	Pocket tape recorder Personal computer AF full-automatic camera	Video game Microwave ovens in 30% of households	
1980	Game watch	Sports drink	On-line cooperation of city banks begins
1981	Optical video disc Video camera for home use Electronic mosquito killer		
1982	TV watch Home "karaoke" CD player One-liter car		Tohoku Shinkansen Line opened Joetsu Shinkansen Line opened
1983	Game computer for home use		
1984	Telephone prepaid card		NHK satellite broadcasting begins test transmission
1985	Electronic clinical thermometer AF full-automatic SLR camera Satellite broadcasting		Plaza Accord NTT and Japan Tobacco privatized
1986	Large-screen TV Liquid crystal TV Systematic notebook One-time use camera		
1987	Automatic bread maker for home use Electronic notebook Bio detergent	Water front development	
1988	Cordless telephone Small portable VCR		Seikan Tunnel opened Seto Bridge opened
1989	8-mm video camera Book-size computer	Fuzzy and neuro-controlled appliances in boom	

Source: Sogo Kenkyu Kaihatsu Kiko, "Seikatsu Suijun no Rekisiteki Bunseki" (A Historical Analysis of Living Standards); Economic Planning Agency, "White Paper on People's Living 1990"; Jiyu Kokumin Sha, "Gendai Yogo no Kiso Chishiki" (Basic Knowledge of Modern Terms).

Fig.2-1　Linear Model

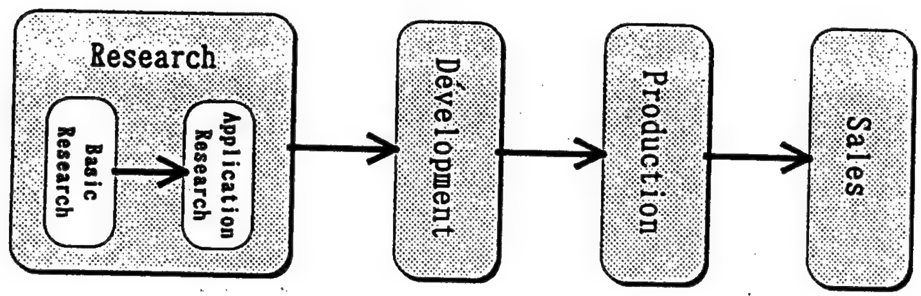
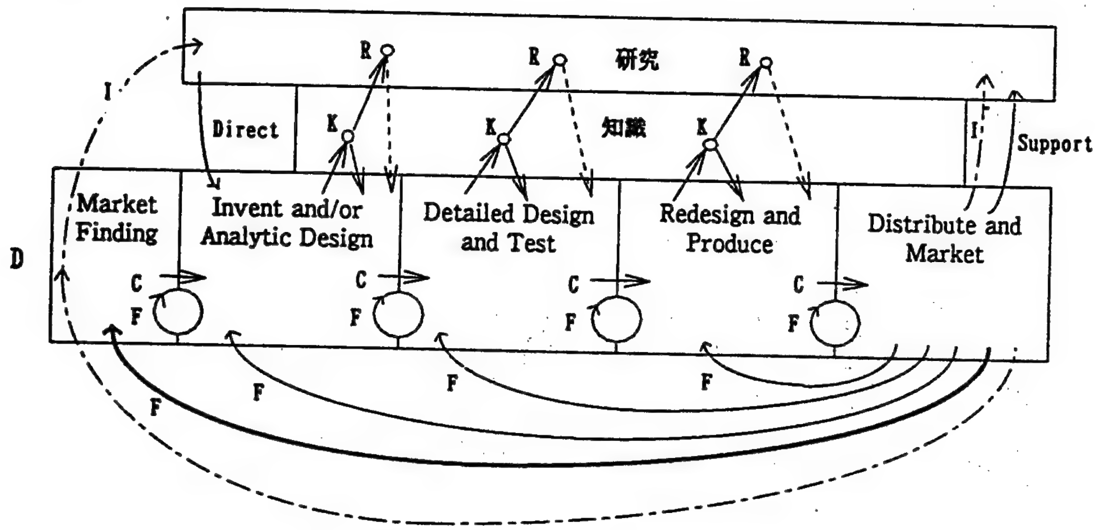


Fig2-2　Example of the Models for Innovation Processes

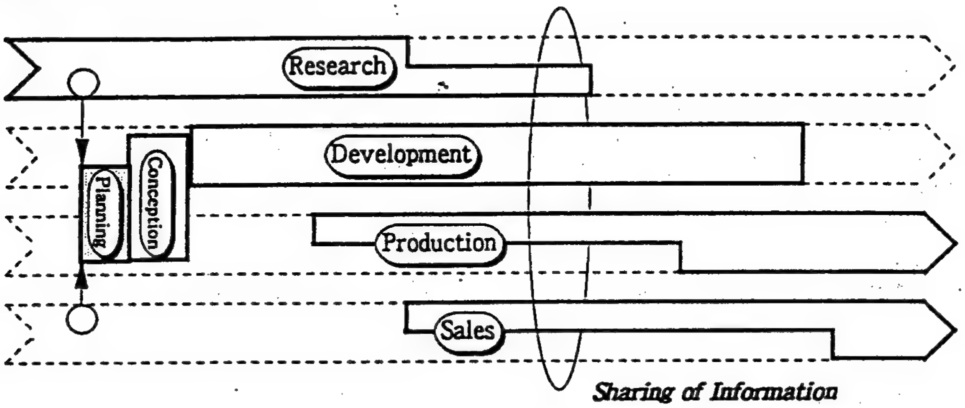
a)Chain-Linked Model



D:Development　K:Knowledge　R:Research
C:Chain　F:Feedback　I:Initiation

Compiled by AIST.Technology Research and Information Division from Stephen J. Kline : Innovation is not a Linear Process　(Research management 28(4).1985)

b)Concurrent System Model



Compiled by AIST.Technology Research and Information Division from Ryo Hirasawa: "The Concept of R&D Management Sprouting in Japan" (Proceedings of Research and Technology Planning Society, May 15, 1992).

c)Spiral Model

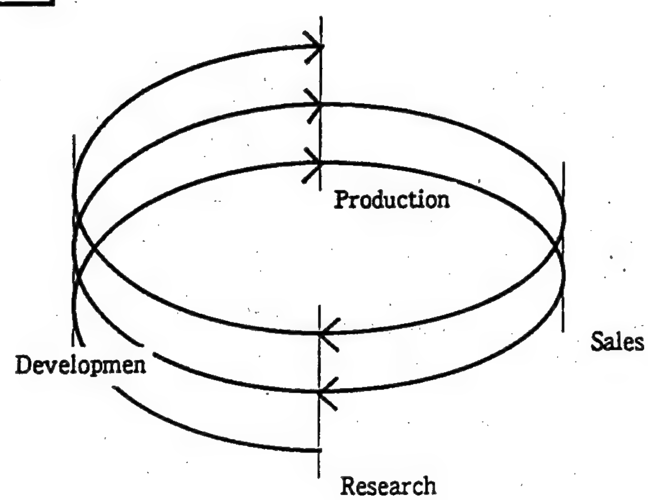
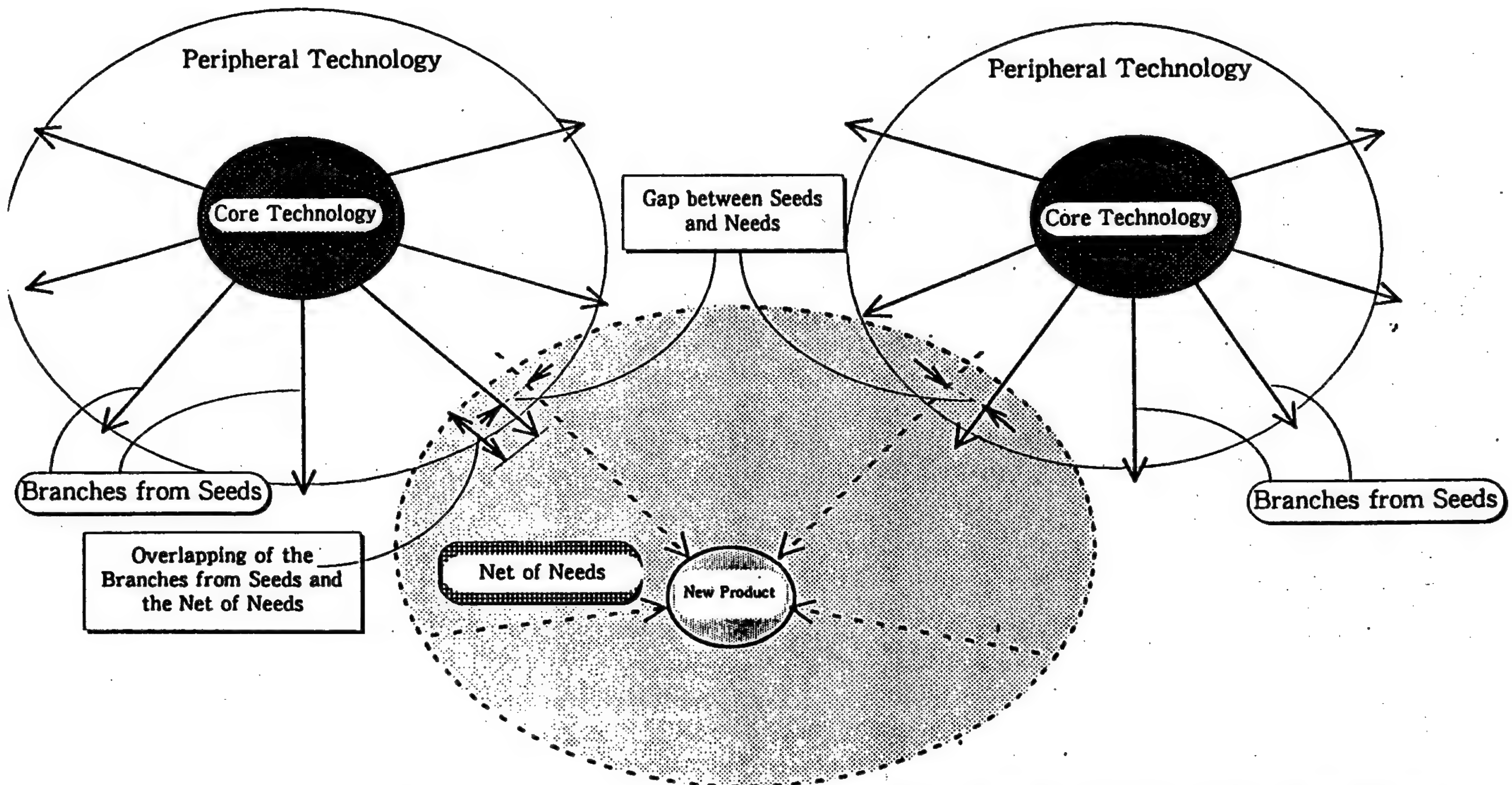
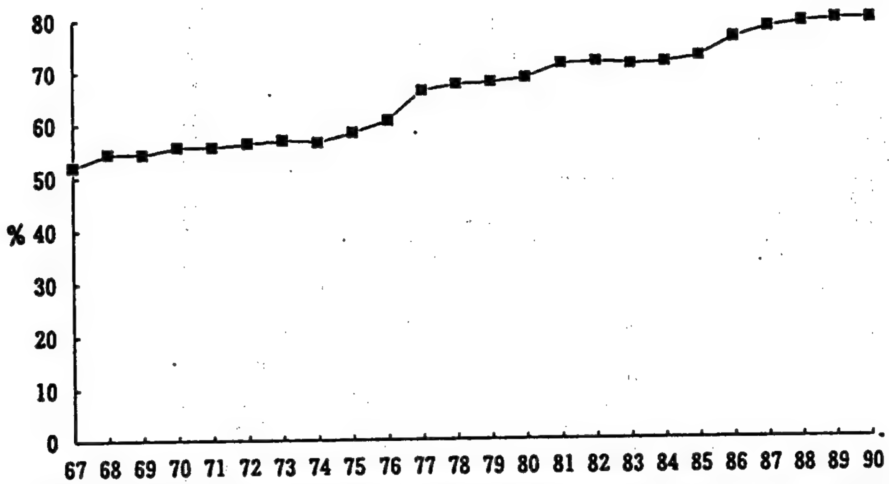


Fig.2-3 A Model for the Process of Acquiring New Technological Options in the Development of Products



AIST, Technology Research and Information Division [1992]

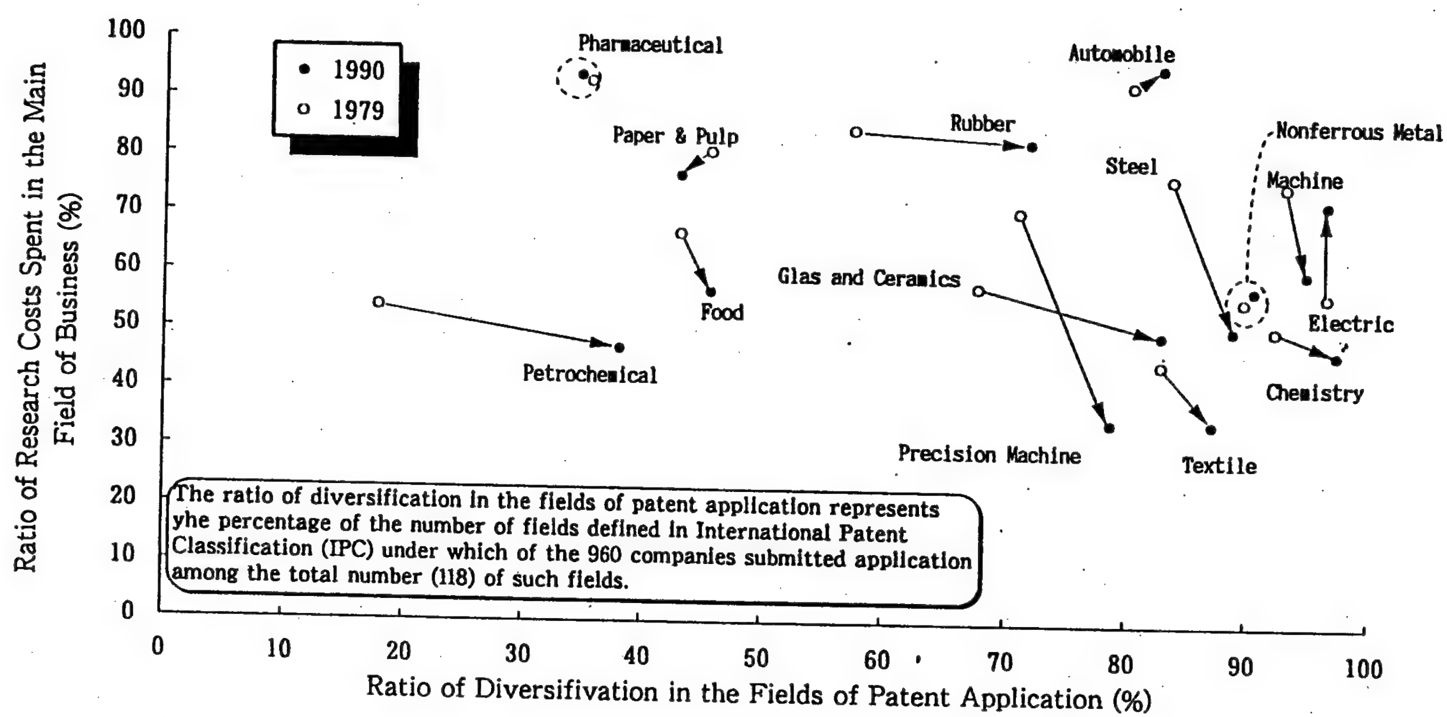
Fig.2-4 Changes in the Percentage of Patents with Subclassifications



The percentage of patents having subclassifications in each year among the total number of patents registered in and after 1980 and those retaining validity as of 1980.

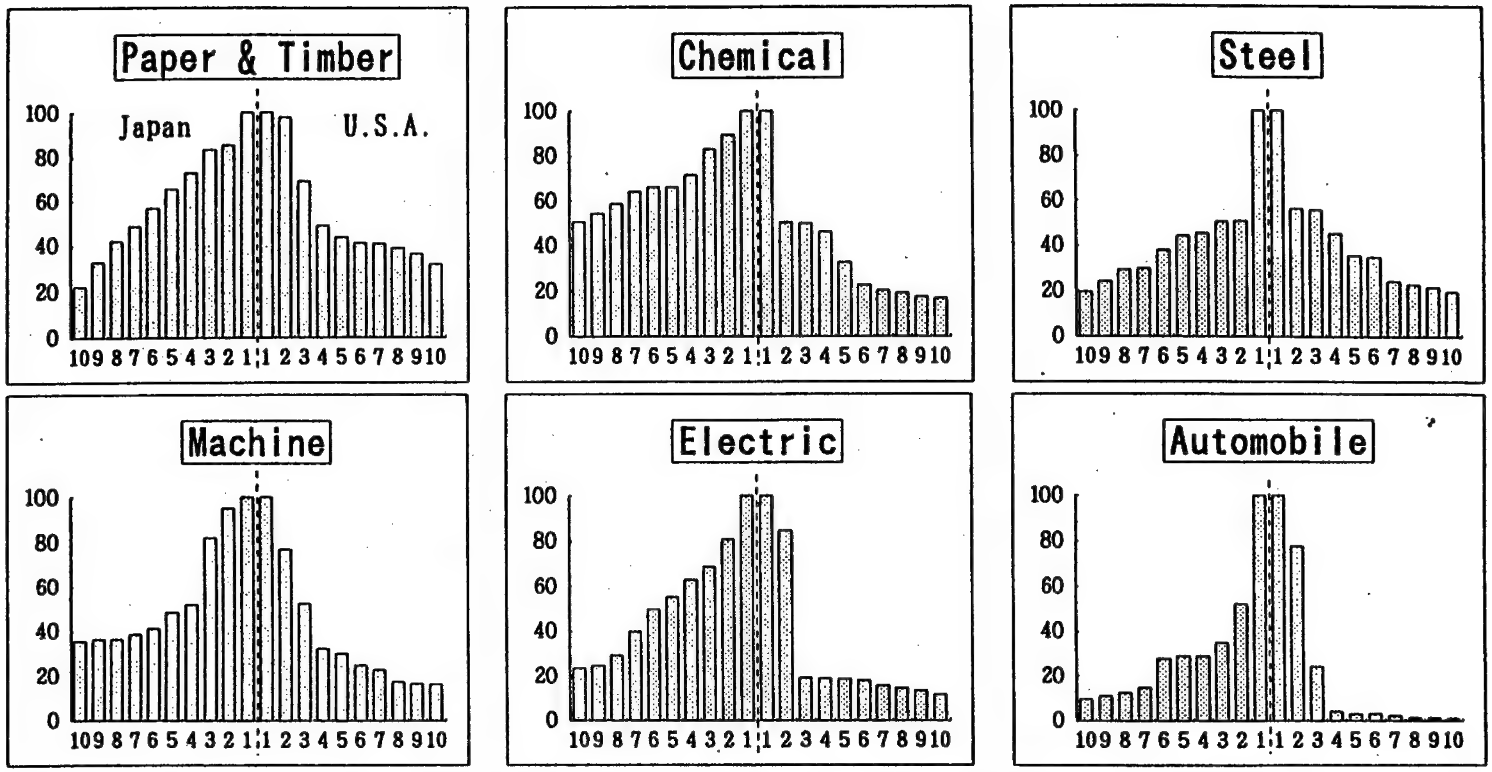
Compiled by AIST, Technology Research and Information Division based on the data from Patent Office [1992]

Fig.2-5 Diversification of Research and Development in Each Industry



Compiled by AIST, Technology Research and Information Division from Management and Coordination Agency, "Report on the Survey of Research and Development " ; corporate finance data from The Nihon Keizai Shimbun; and the data from Japan Patent Information. Organization[1992]

Fig.2-6 Sales Figures of Top 10 Japanese and U.S. Companies



The above figure illustrates the scale of the top ten Japanese and American companies in each industry. For Japan and for the U.S., the sales figures for each company is measured against the figures for the company having the largest sales in each industry, which has the standard value of 100. Companies are arranged symmetrically on both sides of the center line.

Compiled by AIST, Technology Research and Information Division based on the data from FORTUNE500 (1991) and Toyo Keizai Shimpo Sha (1991)

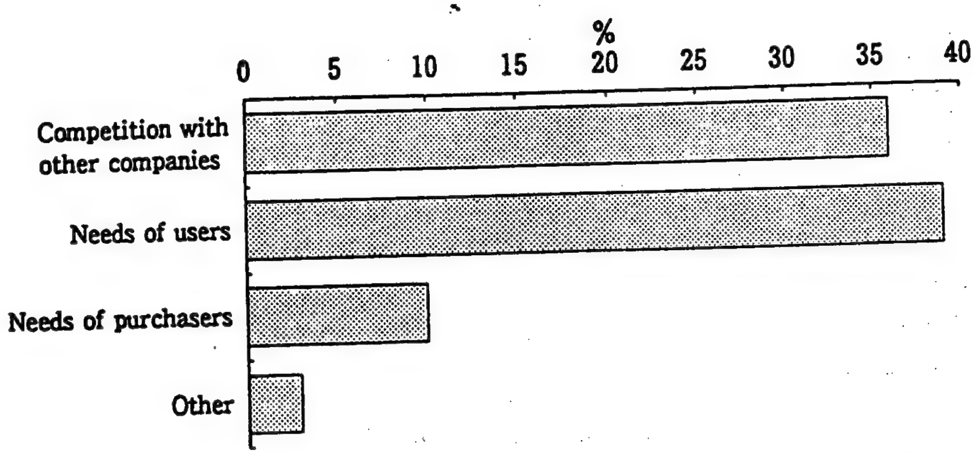
Table 2-1 Estimated Number of Competing Companies in Japan

Air conditioner for home use	18
Motorcycle	5
Piano	3
Synthesizer	5
Car	9
Personal computer	19
Camera	14
Video camera	24
VTR	13
TV set	15
Facsimile	23
DRAM	16
Machine tools	59
Carbon materials	11
Copier	13
Basic textile products	23

The number of competing companies was estimated by looking into Nikkei New Products File from Nikkei Telecom. Data of products marketed in and after January 1991 were retrieved using the key word for the name of each product. Machine tools include lathe, drilling machine, boring machine, miller, grinder, MC, electric spark machine, CO2 laser machine and other machine tools. Basic textile products include yarn, fabric, unwoven fabric, and other basic textile products.

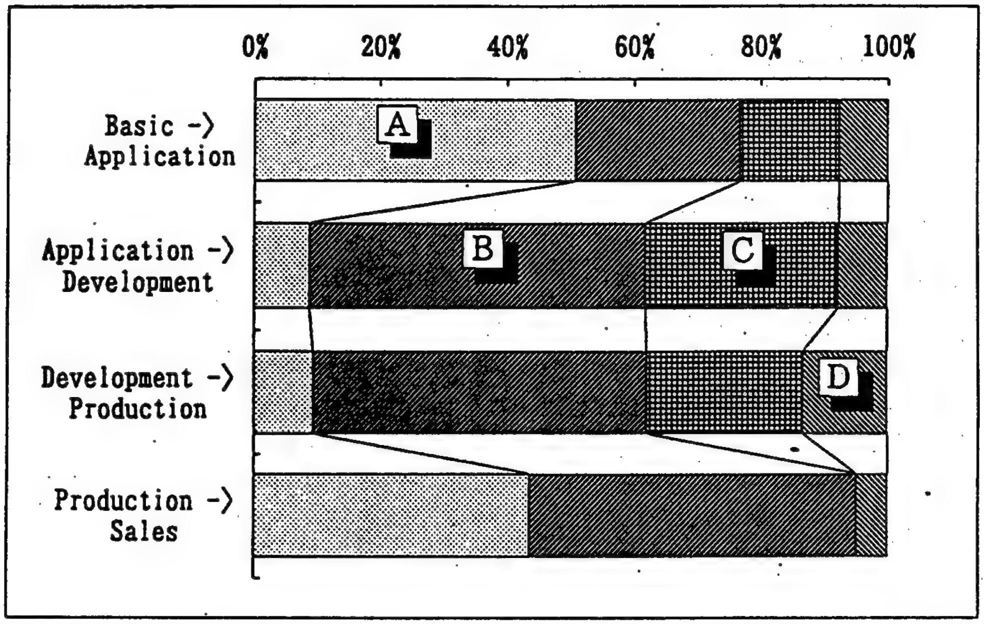
Compiled by AIST, Technology Research and Information Division based on the data from Nikkei Telecom (New Products File).

Fig.2-7 Motivation for Technological Development in Private Companies



Compiled by AIST. Technology Research and Information Division based on a questionnaire research [1992]

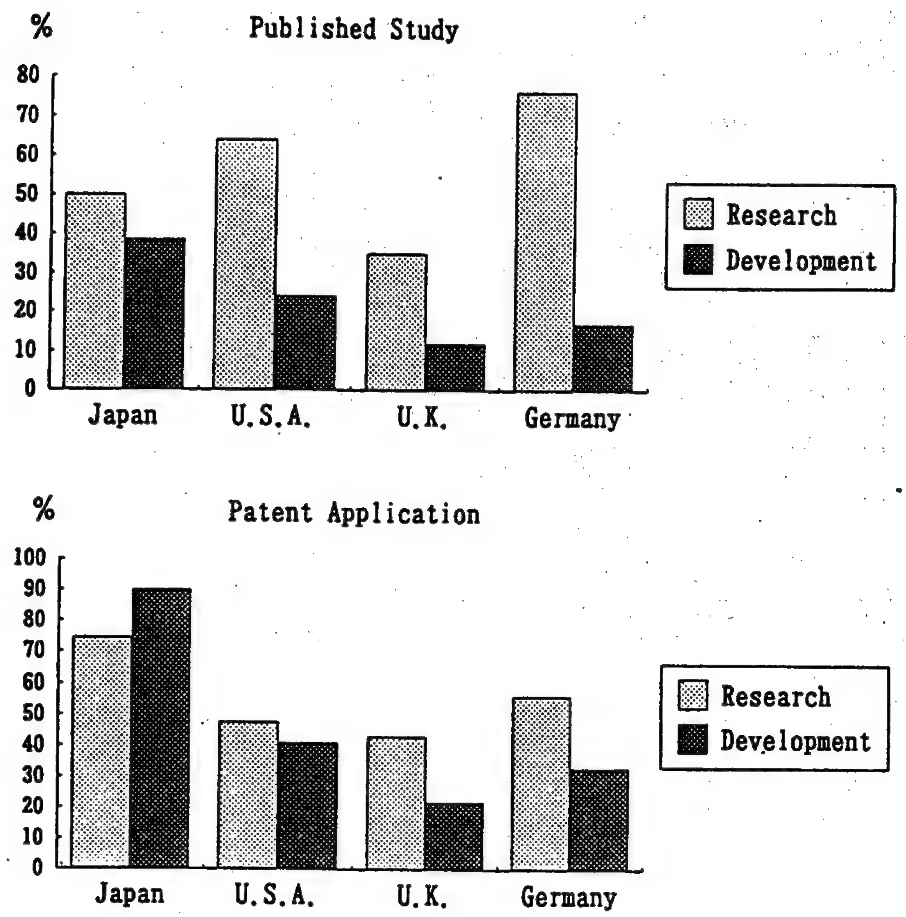
Fig.2-8 Utilization of Manpower in Technology Transfer



A:Technical information is transfered by study reports, manuals and other documented information.
B: Members of the two sections work in temporary collaboration, which ends when technology transfer is completed.
C: Some members of the former section move to the latter section. They transfer technical information to other members of the latter section while activities are continued.
D: All of the core members of the former section move to the latter section and continue activities.

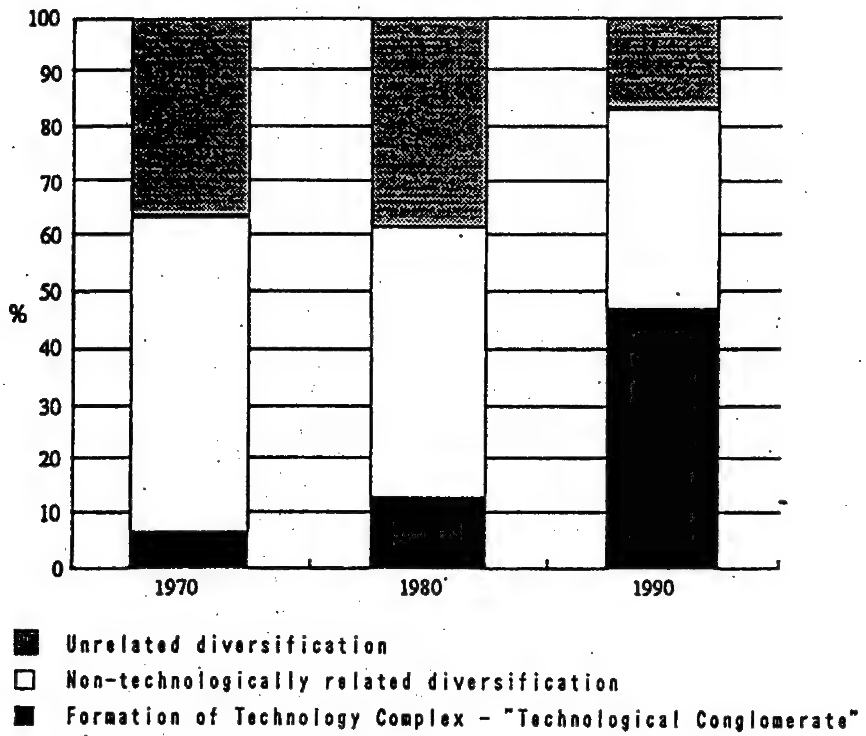
Compiled by AIST, Technology Research and Information Division based on questionnaire research [1992]

Fig. 2-9 Percentage of Researchers Having Published Studies and Patent Applications



Compiled by AIST, Technology Research and Information Division from "American Engineers and Japanese Engineers" (Japan Productivity Center); "German Engineers and Japanese Engineers" (Japan Productivity Center); and "British Engineers and Japanese Engineers" (Japan Productivity Center) [1992].

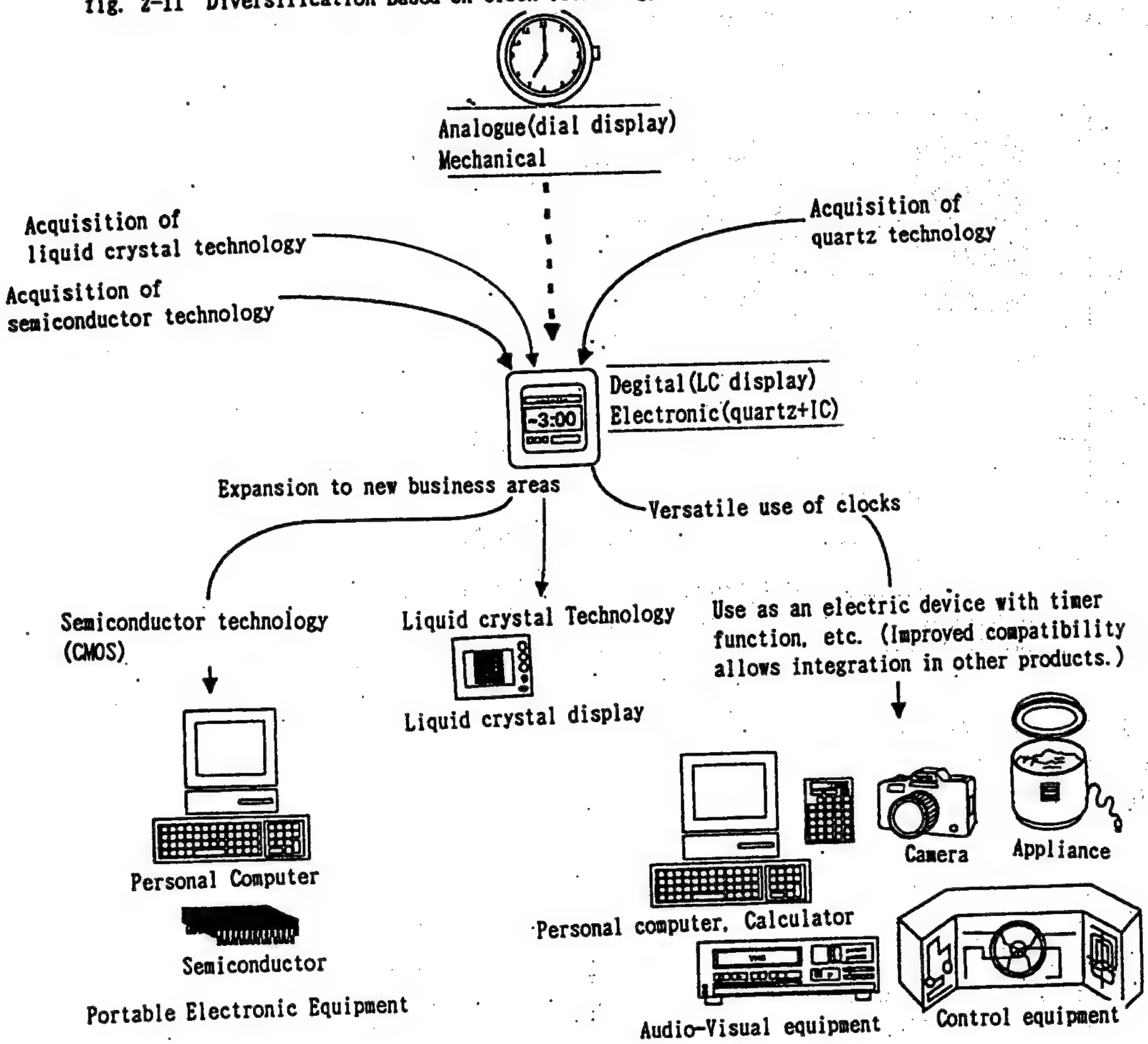
fig. 2-10 Changes in the Form of Diversified Operation



Type of Diversification	Description	Examples
1. Formation of Technology Complex	Expansion to different business areas, where apparent relation with main business is lacking, but deeply connected in bonds of technology	·From food industry to pharmaceuticals. ·From optical industry to aligner for semiconductor etc.
2. Non-technologically related diversification	Expansion to different business areas which are related to main business in terms of plants or market, such as in the utilization of idle resources, by-products, etc.	·From paper industry to timber or wood products ·A railroad company selling soft drinks etc.
3. Unrelated diversification (Conglomerate)	Expansion to different business areas which are not related to main business, in terms of plants, market, technology, etc.	·From sugar industry to athletic gym ·A petroleum company utilizing idle land etc.

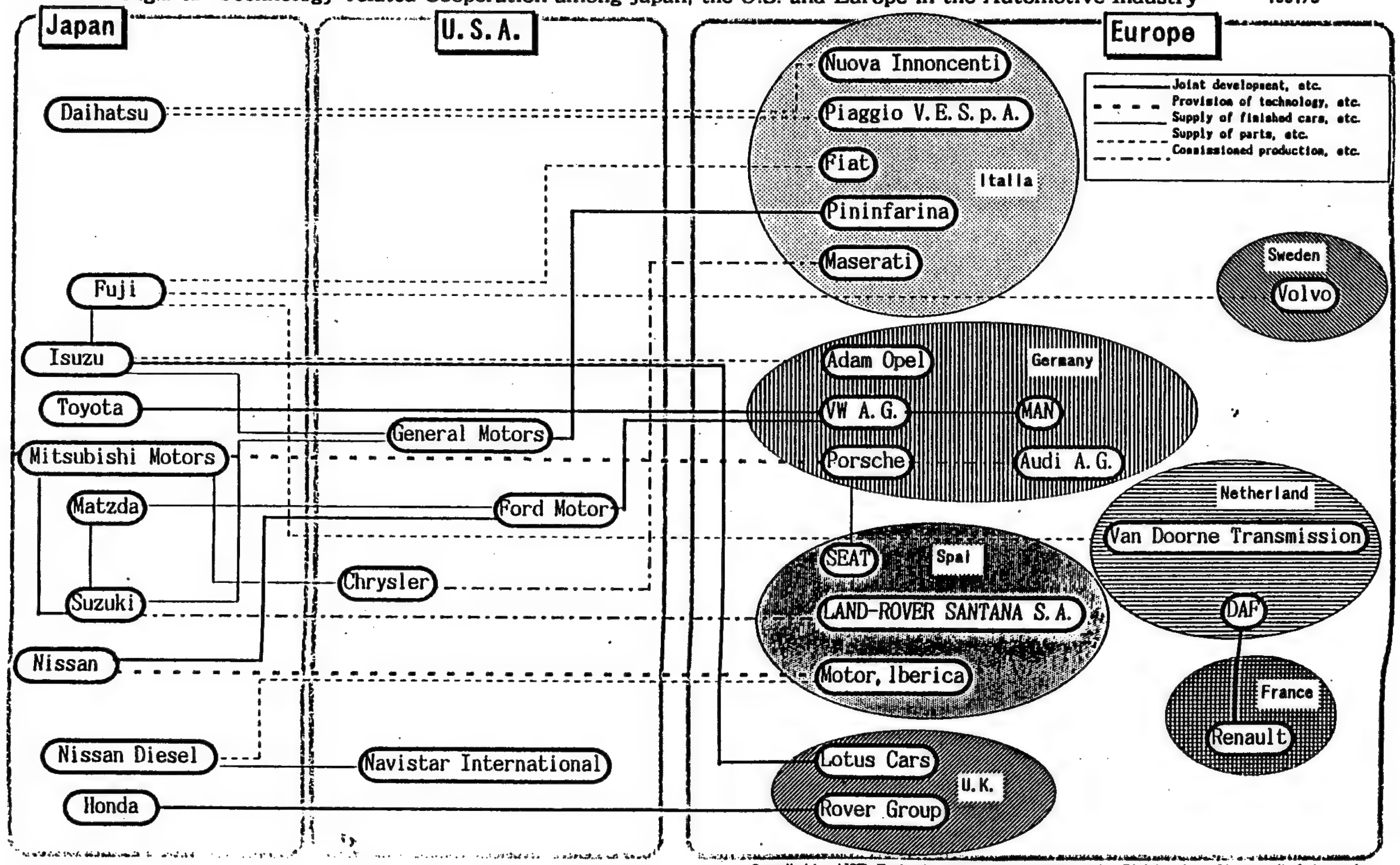
note: The types of diversification were determined based on the data from securities reports of 1,598 listed companies, considering the composition of sales, history and technological relation to main business.

fig. 2-11 Diversification Based on Clock Technology



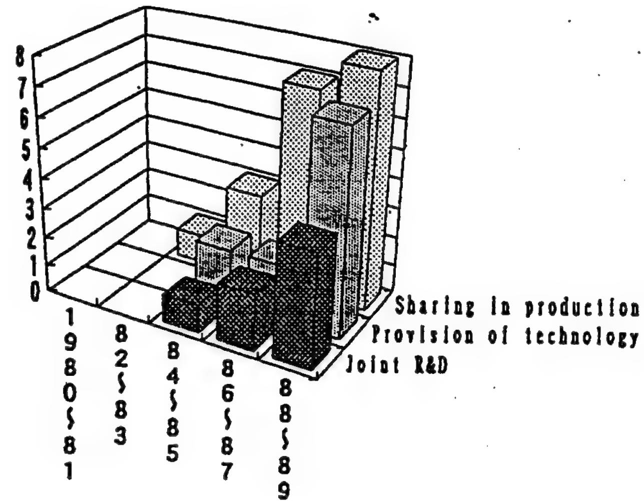
Compiled by AIST, Technology Research and Information Division [May, 1992]

Fig.2-12 Technology-related Cooperation among Japan, the U.S. and Europe in the Automotive Industry 1991/3



Compiled by AIST, Technology Research and Information Division from "Automobile Industry in Japan" (Japan Automotive Manufacturers Association, Inc.)

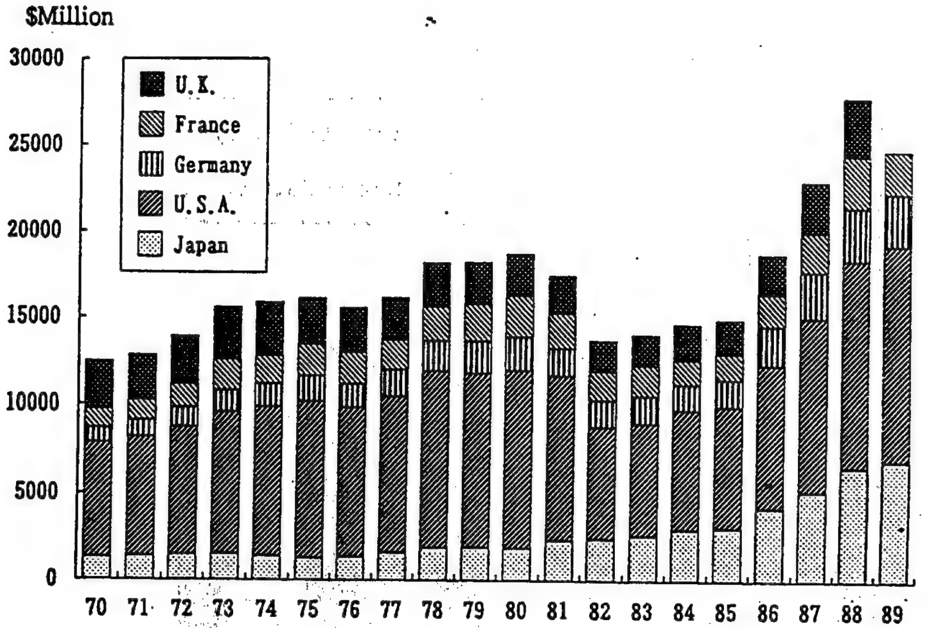
fig. 2-13 Growth of International Cooperation
by Semiconductor Manufacturers in Japan



(Only publicly announced cooperation is included)

Compiled by AIST, Technology Research and Information Division from Electric Industries Association of Japan "IC Guide Book '91"

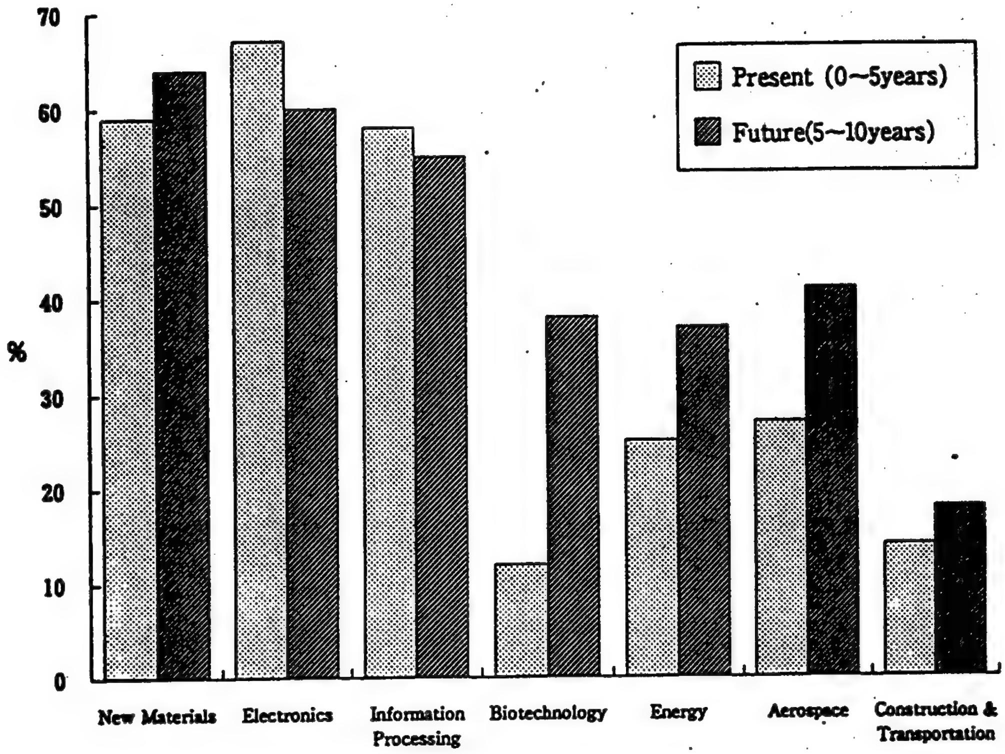
Fig. 2-14 Changes in the Amount of Technological Trade in Selected Western Countries



The amount of technological trade is the sum of the amount of imported and exported technologies. Therefore, trade among the five countries has been counted twice.

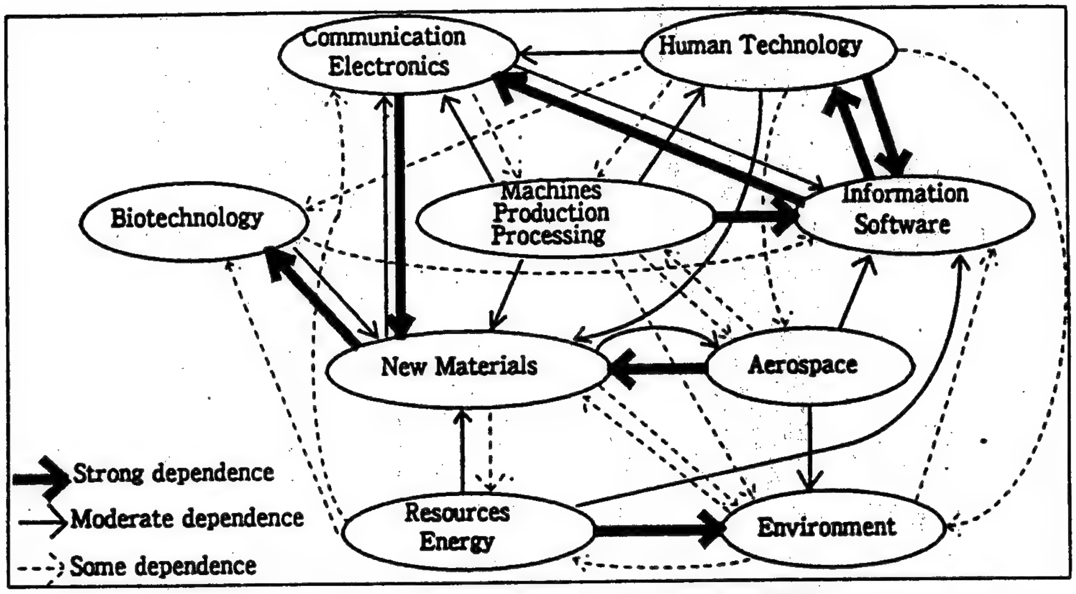
From "White Paper on Science and Technology 1991." Values have been converted with IMF rates (real value in 1985).
(The amount of British technological trade in 1989 is unknown.)

Fig. 2-15 Promising Fields of Technological Advancement Expected to Induce Industrial Development



Compiled by AIST, Technology Research and Information Division from a survey on the interaction among important fields of high-technology (Economy Research Institute,Japan Society for the Promotion of Machine Industry) [1992].

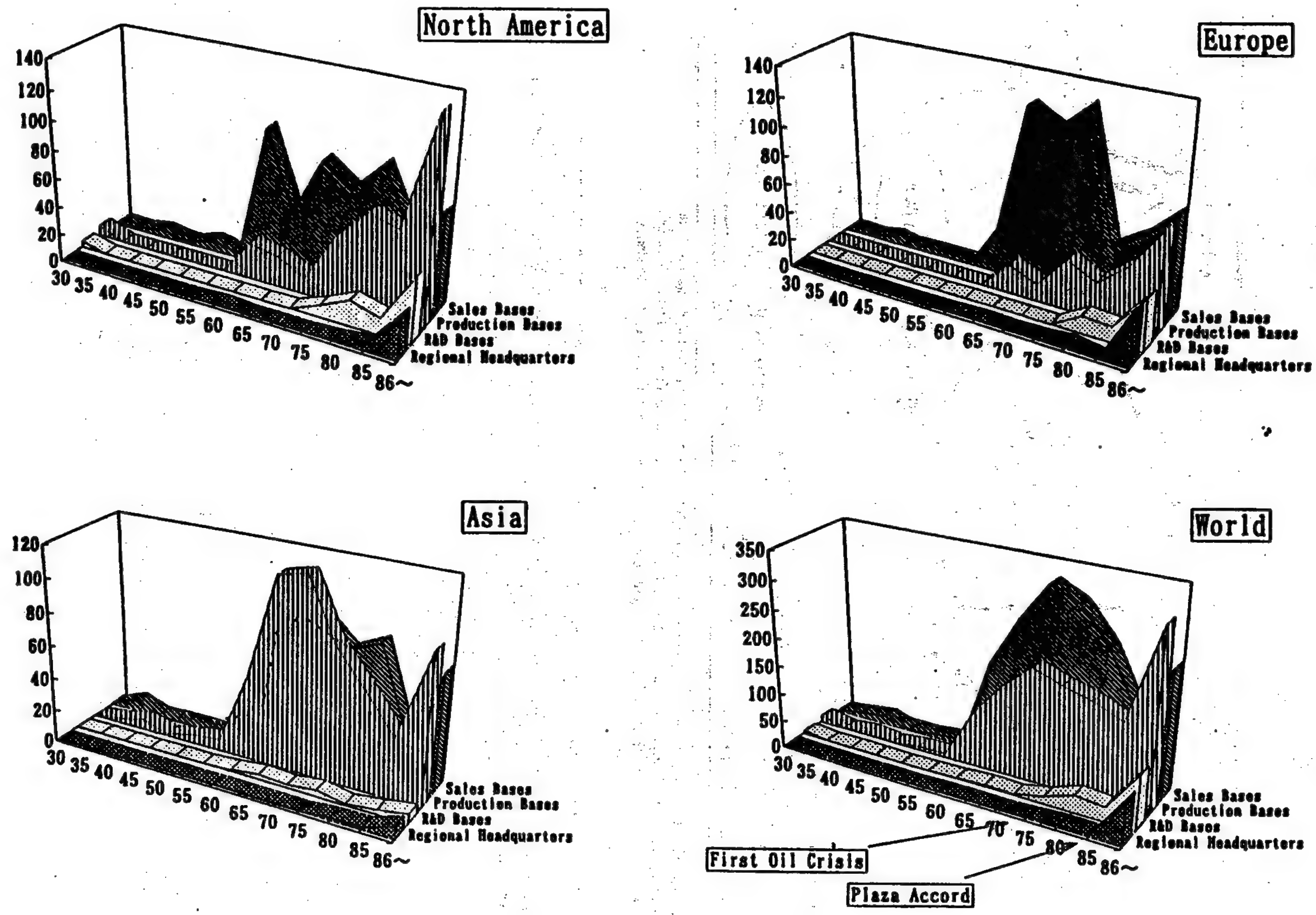
Fig. 2-16 Interdependence of the Areas of Research and Development



Strong dependence: In more than one area in a field, over 50% of researchers indicated dependence.
Moderate dependence: In more than one area in a field, over 30% of researchers indicated dependence.
Some dependence: In more than one area in a field, over 10% of researchers indicated dependence.

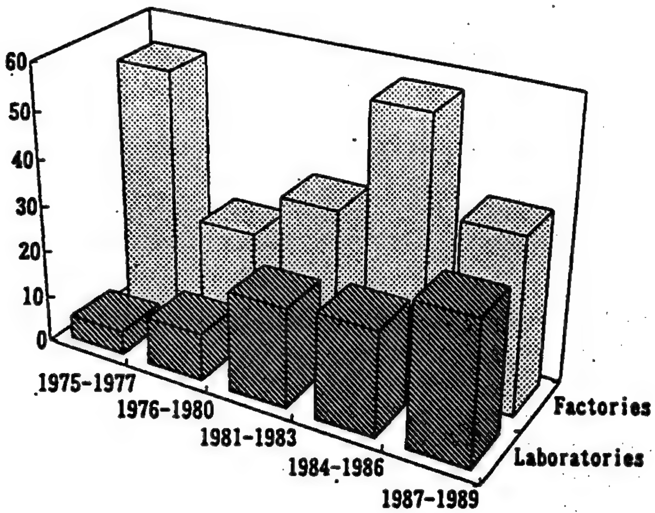
Compiled by AIST, Technology Research and Information Division based on a questionnaire survey.[1992]

Fig. 2-17 Globalization of Japanese Companies



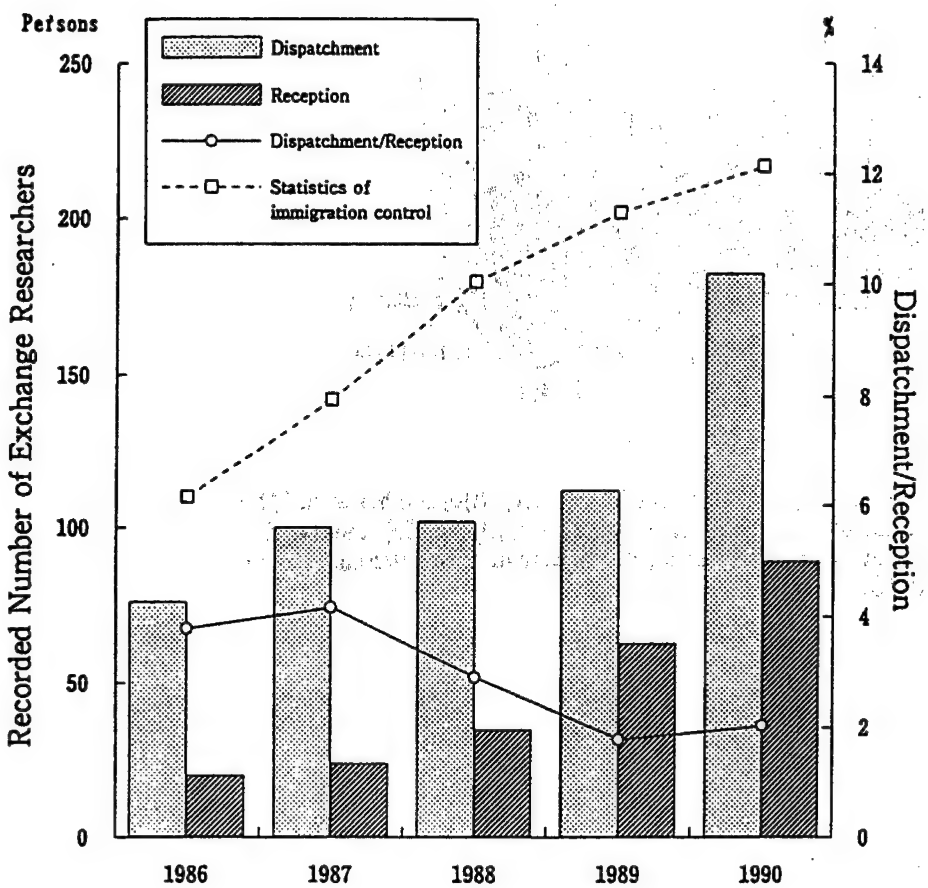
Compiled by AIST, Technology Research and Information Division based on "Study Report on the Advancement of Globalization and Industrial Technology" (Mitsubishi Research Institute) [1992].

Fig. 2-18 Advancement of International Investment to Japan



Compiled by AIST, Technology Research and Information Division based on "The 24th Survey of Business activities of Foreign Affiliates in Japan", (Ministry of International Trade and Industry, Industrial Policy Bureau, International Business Affairs Division) [1992]

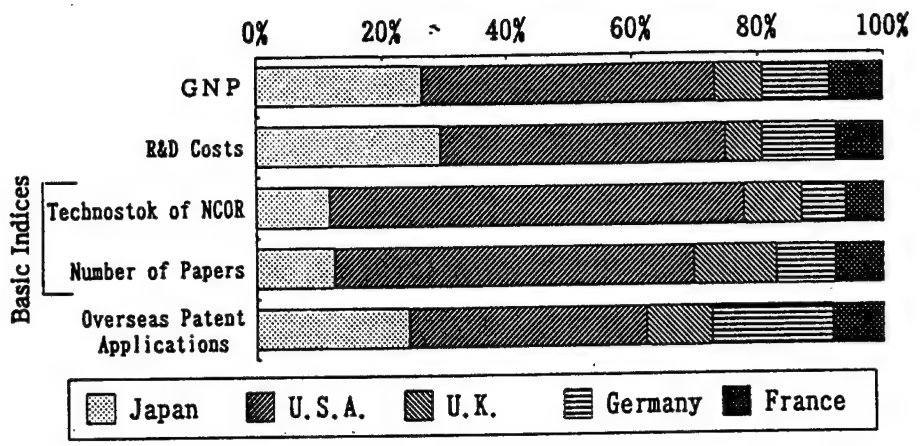
Fig. 2-19 Exchange of Researchers between Japan and Other Developed Countries



Basing on histrical data from 50 companies, which employ more than 30 researchers and experienced in 1990 researcher exchange (accepting or sending) longer than 6 months.

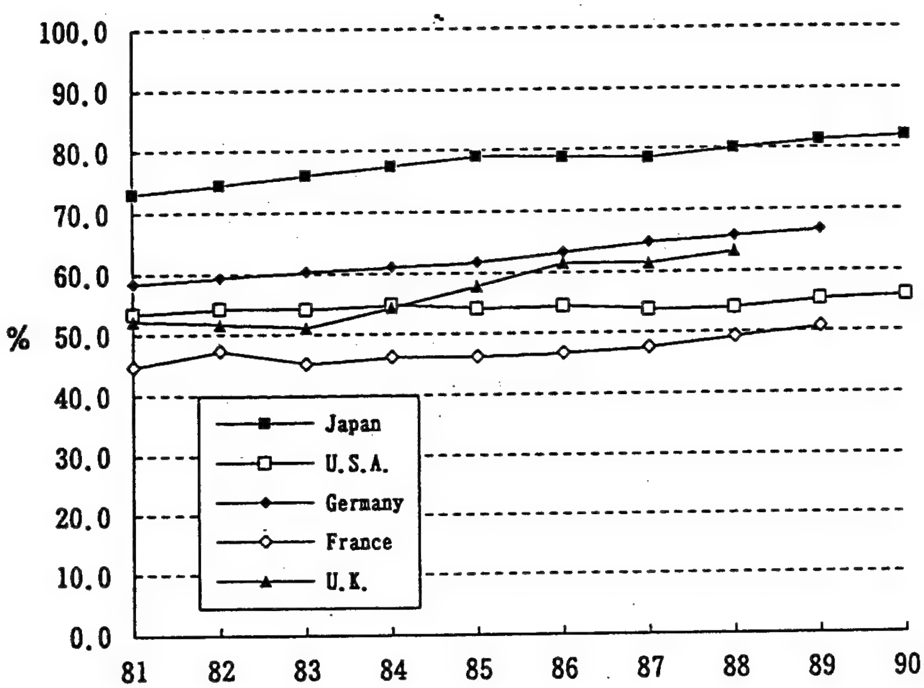
Compiled by AIST, Technology Research and Information Division based on "Towards the New Development of the Exchange of Researchers -- An Interim Report on International Exchange of Researchers" (MITI, AIST) and "The Annual Statistics of Immiguration Control" (Ministry of Justice) [1992]

Fig. 2-20 Japanese Contribution to Research and Development Activities



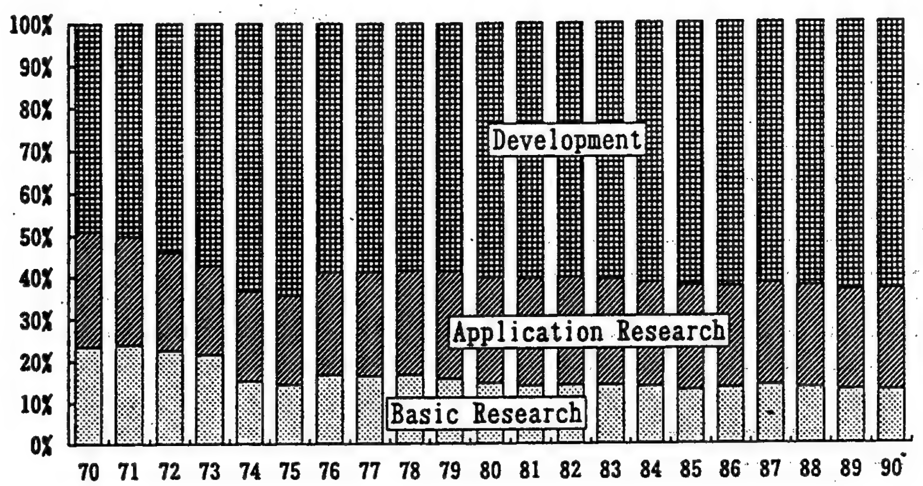
Compiled by AIST, Technology Research and Information Division [1992] based on:
GNP: White Paper on Science and Technology 1991 (values for 1989)
Research and Development Costs: White Paper on Science and Technology 1991 (values for 1989)
Technostock of Science Accumulation Type: Basic Research on the Future Prospects of Science and Technology (Mitsubishi Research Institute) (values for 1988)
Number of Academic Papers: Estimation by Mitsubishi Research Institute from SCISEARCH (values for 1990)
Overseas Patent Applications: Journal of Patent Office (values for 1988)

Fig. 2-21 Contribution of the Private Sector to Research Expenditure



Compiled by AIST, Technology Research and Information Division based on "Research on Scientific and Technological Studies" (Management and Coordination Agency) and "White Paper on Science and Technology" (Science and Technology Agency) [1992]. Part of the data is estimations.

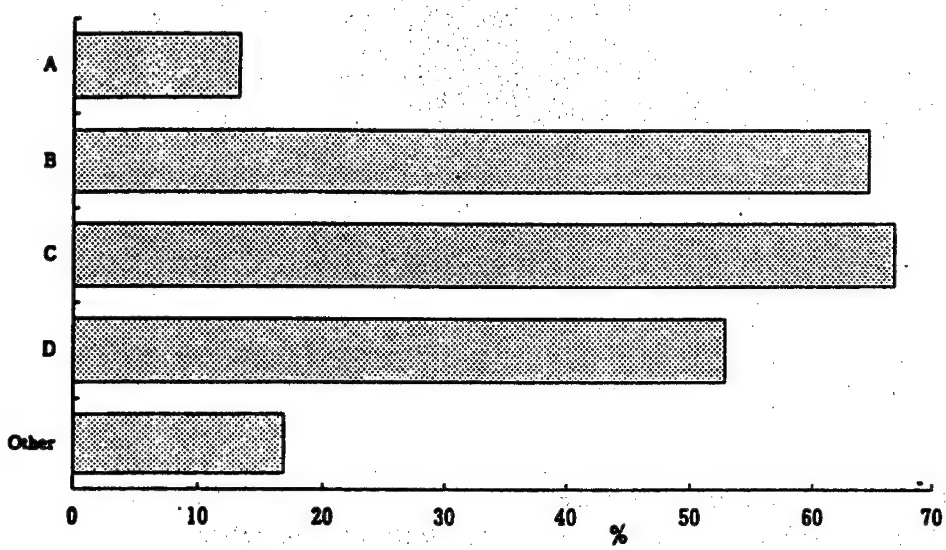
Fig. 2-22 Distribution of Japanese Research and Development Expenditure amongst Basic, Applicational, and Developmental Studies



Compiled by AIST, Technology Research and Information Division from "Research on Scientific and Technological Studies" (Management and Coordination Agency).

Fig. 2-23 Recognition of "Basic Study" by Companies

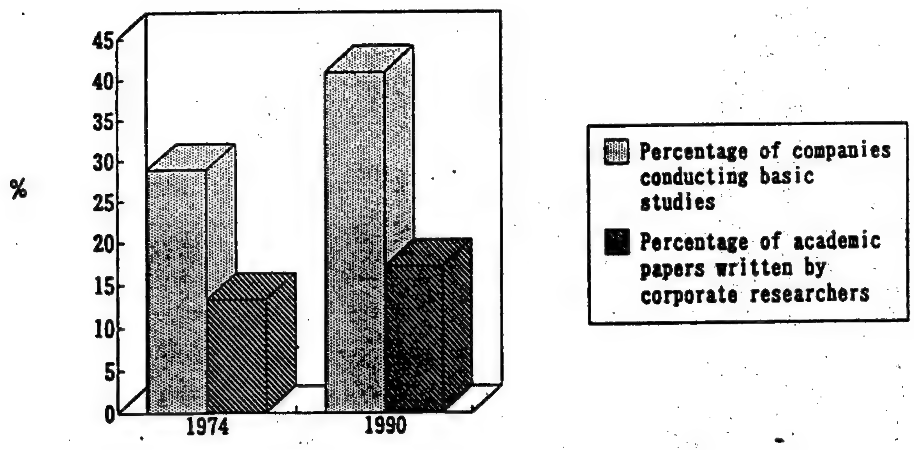
(Multiple answers)



A:Enhances the understanding of natural science.
B:Contributes to the business in the long run, although there is no specific purpose.
C:There is a application purpose, but commercialization is difficult in near future.
D:Does not contribute to the present business, although commercialization is intended.

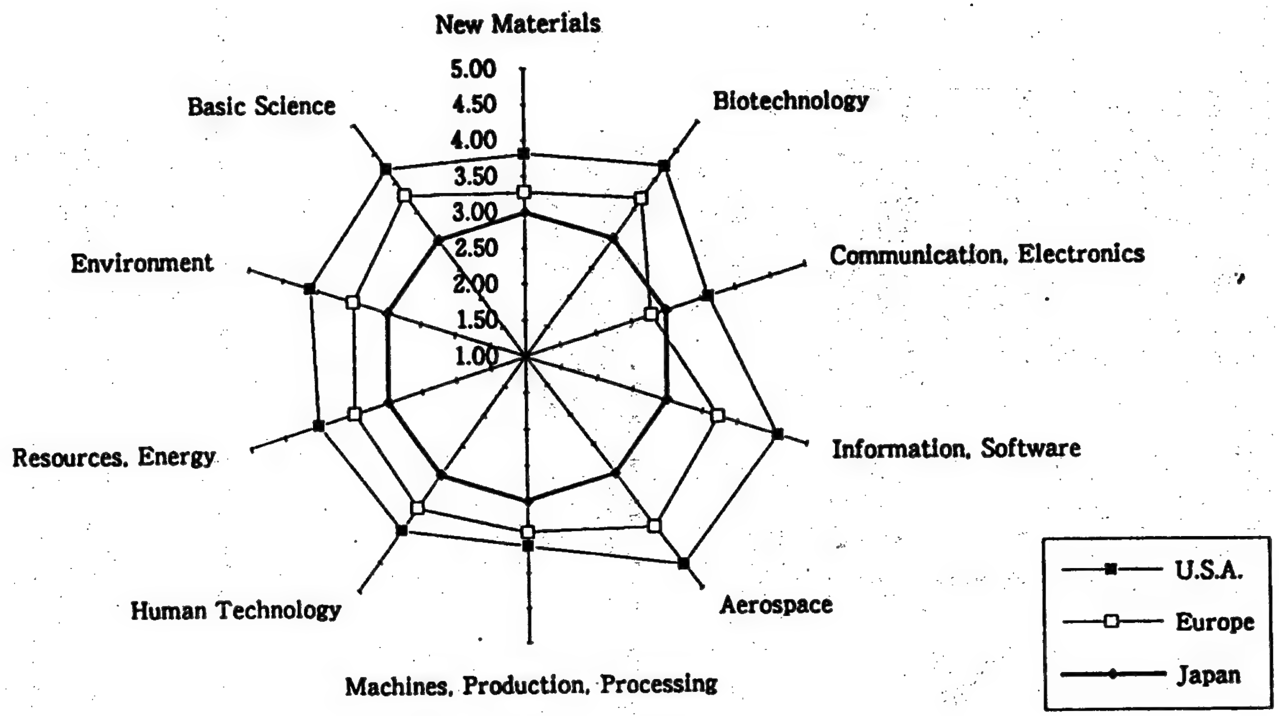
Compiled by AIST, Technology Research and Information Division based on The Research on the Actual State of Basic Studies in Private Companies in Japan (Research and Industry Association).

Fig. 2-24 Percentage of Published Studies Conducted by Corporate Researchers



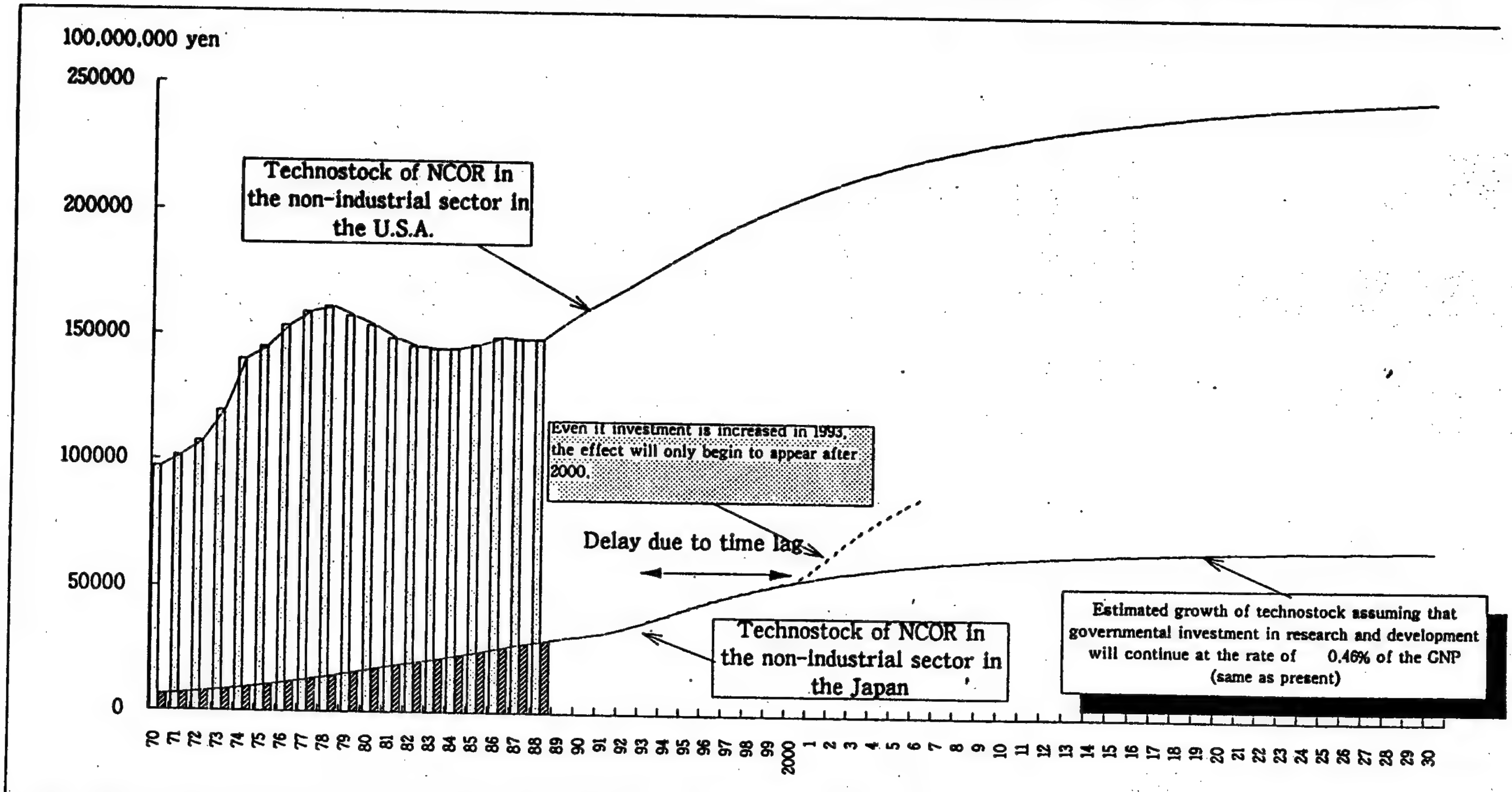
Compiled by AIST. Technology Research and Information Division [1992] based on:
Percentage of companies conducting basic studies: Research on Scientific and Technological Research (Management and Coordination Agency).
Percentage of academic papers written by corporate researchers: Estimation by Mitsubishi Research Institute from SCISEARCH

Fig. 2-25 Tripolar Comparison of the Areas of Research and Environment



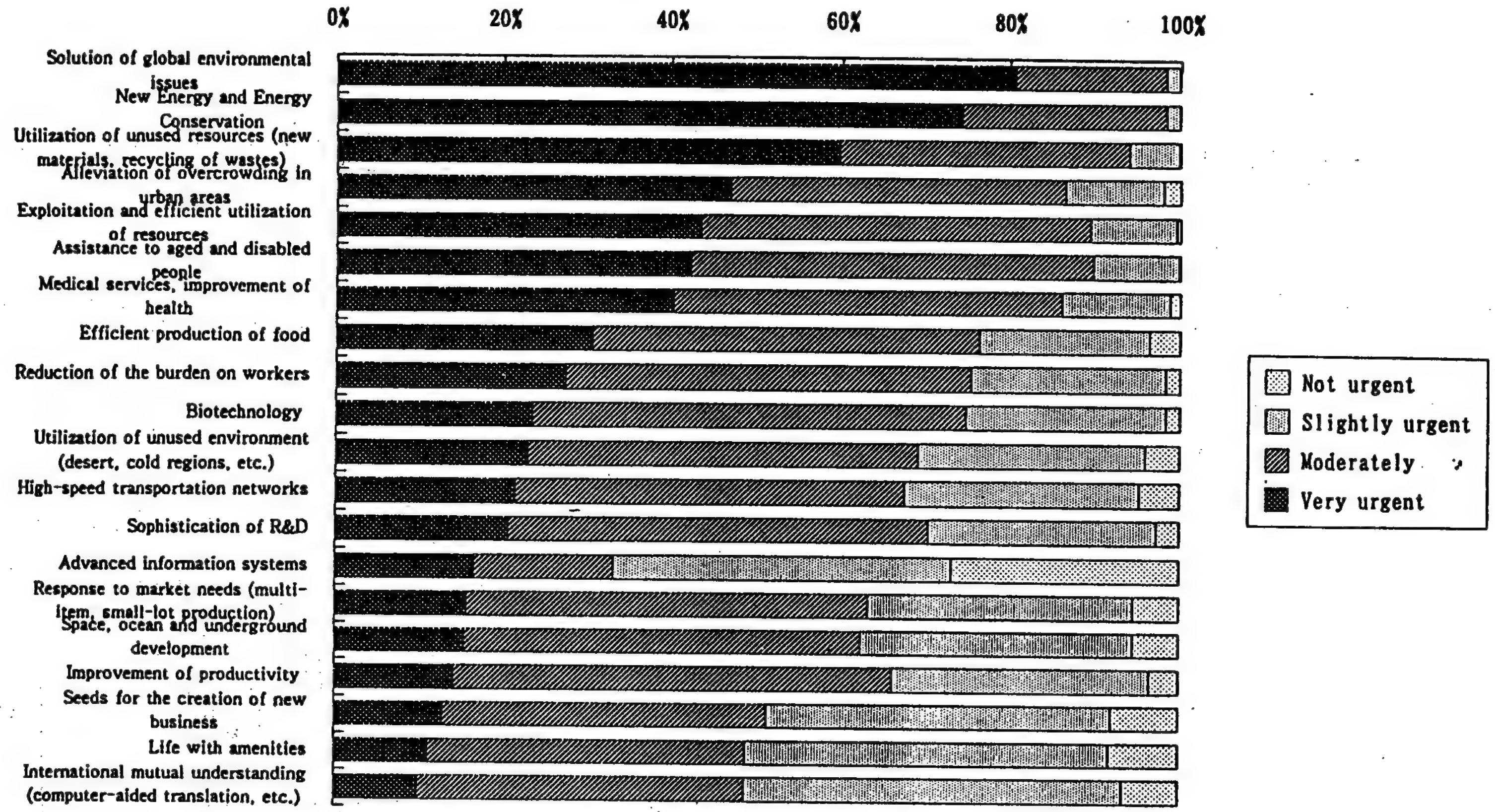
Compiled by AIST, Technology Research and Information Division based on a questionnaire research [1992].

Fig. 2-26 Future Prospects of Technostock of Non-Commercially Oriented R&D (NCOR)



Compiled by AIST, Technology Research and Information Division based on "Research on the Quantitative Comparison of Technostock in Japan and the U.S.A." (Economy Research Institute, Japan Society for the Promotion of Machine Industry) [1992].

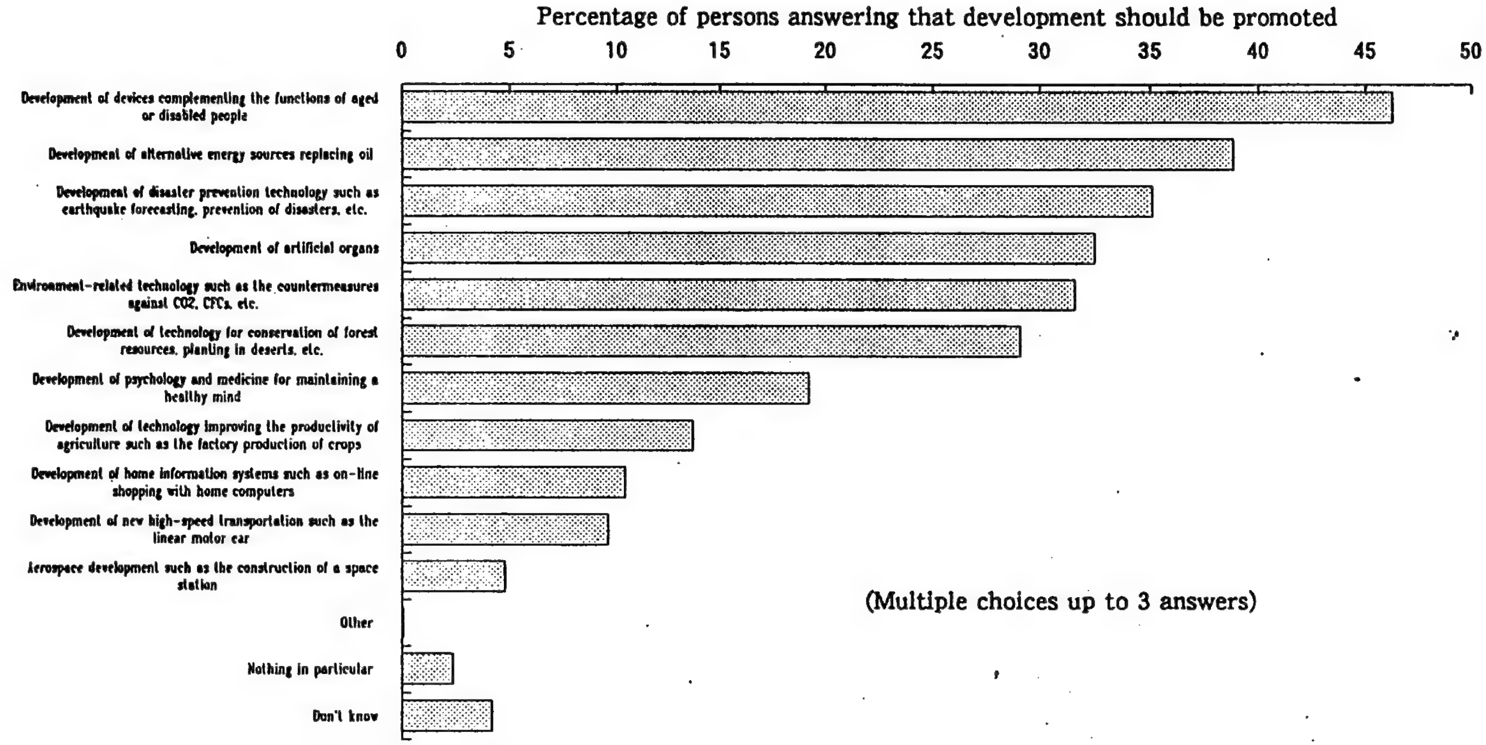
Fig. 3-1 The Degree of Urgency of Nationally-promoted Technological Development Themes



The questionnaire was sent to a total of 3,000 planners in Japanese companies (all of listed manufacturing companies and randomly extracted small companies) and officials of government offices, universities and government-related organizations. Valid answers were obtained from 867 persons.

Compiled by AIST, Technology Research and Information Division from "Study Committee Report on the Trends and Problems of New Industrial Technology" (Economy Research Institute, Japan Society for the Promotion of Machine Industry) [1992].

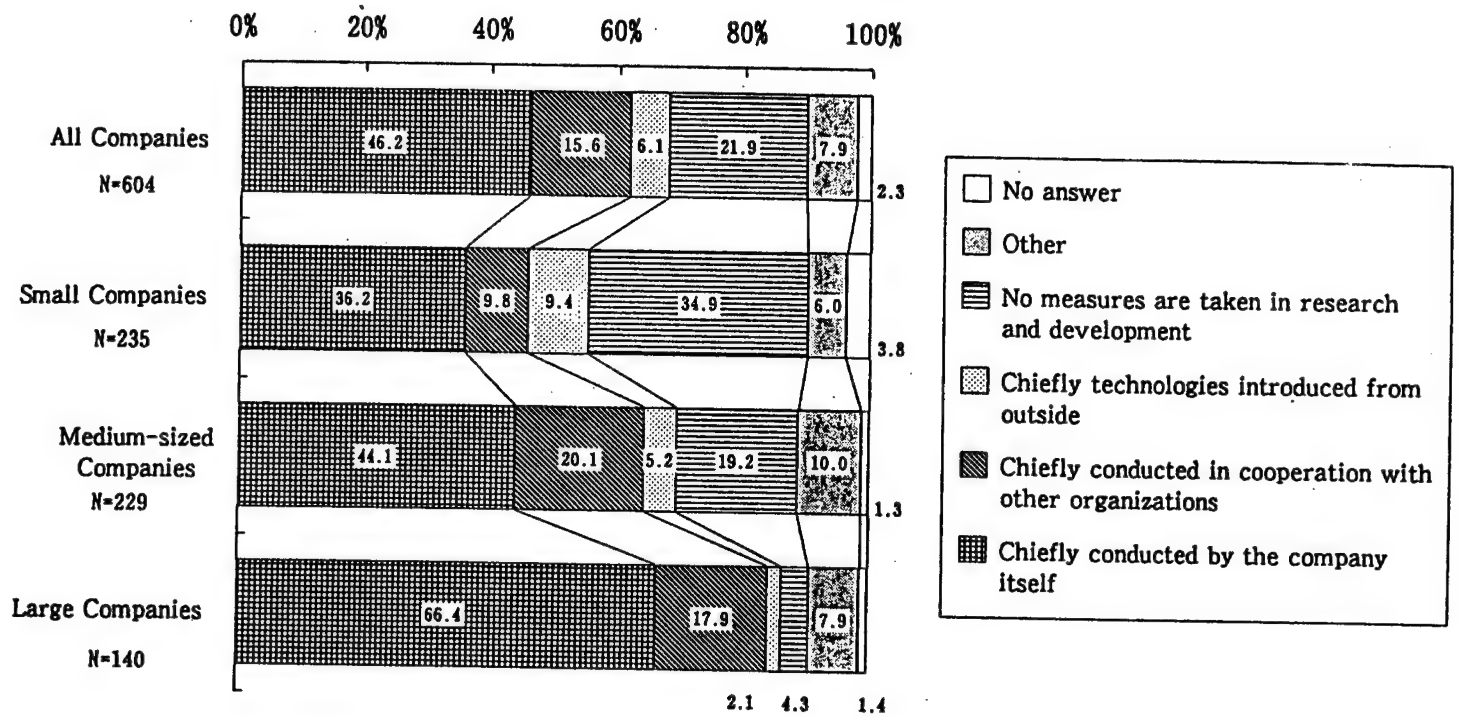
Fig. 3-2 Fields in Science and Technology Which Need to be Developed



The questionnaire was sent to a total of 3,000 Japanese individuals of 18 and older randomly chosen with stratified 2-stage sampling. Valid answers were obtained from 2,239 persons.

Management and Coordination Agency, "Opinion Poll on Science and Technology and the Society" (conducted in January) (1990).

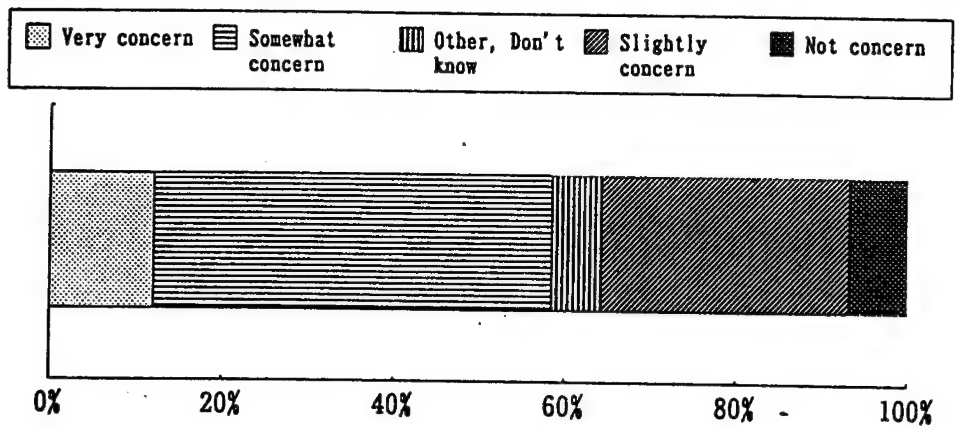
Fig. 3-3 Research and Technological Developments with Environmental Considerations



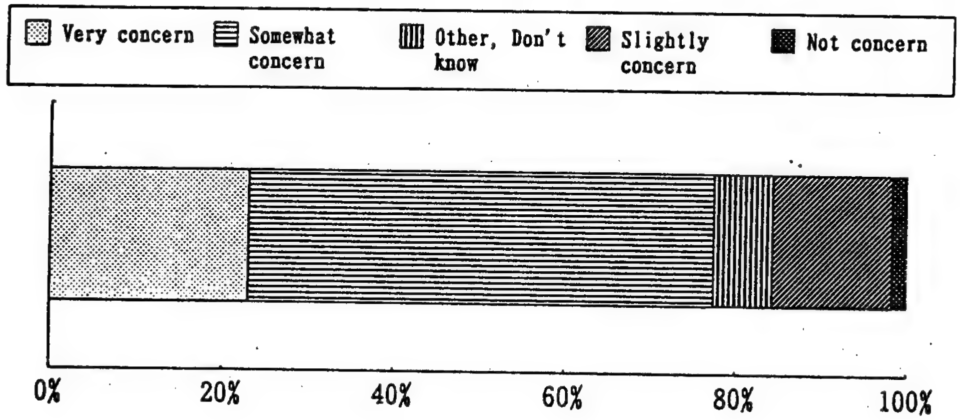
"Fact-finding Study on Technology and Environment in the Era of Global Environmental Issues" (Economy Research Institute , Japan Society for the Promotion of Machine Industry) [1992].

Fig. 3-4 Perception of the Japanese People about Science and Technology

Concern that the progress of science and technology is too rapid for me to keep up with

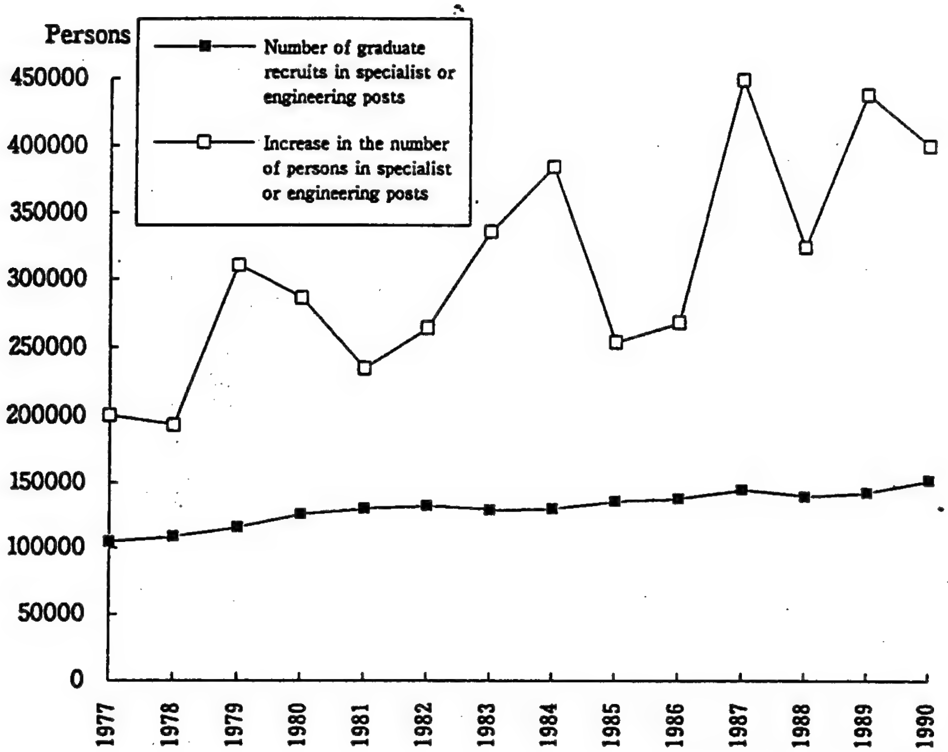


Concern about the possibility of the abuse or misuse of science and technology



Management and Coordination Agency. "Opinion Poll on Science and Technology and the Society" (conducted in January, 1990).

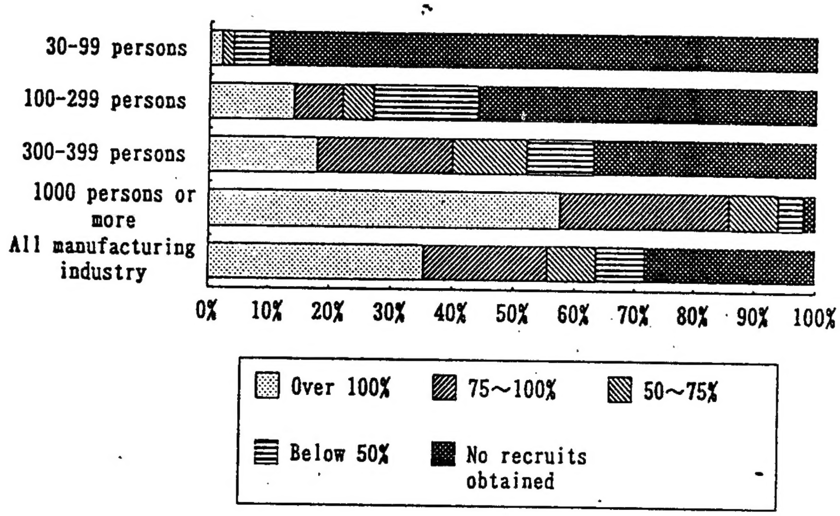
Fig. 3-5 The Gap between the Supply and Demand for Engineers



As for the increase in the number of persons in specialist or engineering posts, the number of new recruits was estimated by adding the annual increase to the estimated number of retiring persons.
The statistical definition of specialist or engineering posts was altered in 1987. The increase (250,000) was compensated.

Compiled by AIST, Technology Research and Information Division based on:
Number of persons in specialist or engineering posts:"Annual Report on Work Force" (Management and Coordination Agency, Statistics Bureau)
Number of graduates (including post-graduates) in specialist or engineering posts: "Basic Research on Schools" (Ministry of Education) [1992].

Fig. 3-6 Recruitment of Graduate Engineers byCompany Size (Percentage of the Number of Unofficially-determined Recruits to the Number of Positions Offered)



Compiled by AIST, Technology Research and Information Division based on "Survey on the Trend of Labor and Economy" (conducted in February, 1992; Monthly Report of Statistic Research on Labor Vol. 44, No. 3) [1992].

Table 3-1 : History of International Discussion Related to the Policies on Science and Technology

Decade	Main Contents of Agenda	Remarks
1960's	Domestic and international science policies Science and economic development	CSTP, 1st Ministerial Meeting (1963)
	Promotion of R&D (Increase in the committment of human and financial resources) Basic research and governmental measures Problems of international cooperation in scientific and technological research	CSTP, 2nd Ministerial Meeting (1966)
	Technology gap among OECD member countries Policies on scientific and technological information	CSTP, 3rd Ministerial Meeting (1968)
1970's	Trends of technology and the goals of R&D Innovation answering to social and economic needs	CSTP, 4th Ministerial Meeting (1971) Pollution problems 1st Oil Crisis
	Management and operation of research systems Science, technology and society Need for public participation (technology assessment) New prospects for natural resources	CSTP, 5th Ministerial Meeting (1975) 2nd Oil Crisis
1980's	Interaction between innovation and economic policies Promotion of innovation (infrastructure and environment) Science, technology and society	CSTP, 6th Ministerial Meeting (1981)
	Examination on technology, employment and culuture	Versailles Summitt, Technology Workshop (1982)
	Beginning of the examination of R&D subsidies and intellectual property rights in relation to international trade	GATT, Uruguay Round (1986)
	Strategy to strengthen the contribution of science and technology to economic grouwth and social development (Promotion of innovation and dissemination etc.) Globalization of science and technology, and its relationship with economic development (The significance of international cooperation in national policies etc.)	CSTP, 7th Ministerial Meeting (1987)
	Well-balanced contribution to basic research and dissemination of the results Promotion of international cooperation (Transfer of scientific and technological knowledge; international protection of intellectual property rights etc.)	CSTP Framework
	Shared responibilities and mutual and equitable contributions and benefits, commensurate with the two nations' respective scientific and technological strengths and resources Comparable access to R&D information	U.S.-Japan Science and Technology Agreement
	Beginning of the examination on the involvement of technology in a wide range of activities including economic activities	OECD, Technology/Economy Program(1988)
1990's	Ensuring the consistency of macro- and micro-economiy, education, employment and regulation policies to promote innovation and dissemination Expansion of the public assistance to basic research Innovation systems and global interdependence	TEP Report (1991)
	Cooperation in big science Development of coopeation with Central and East European countries National innovation systems and international interdependence (Examination of need to develop additional rules of the game)	CSTP, 8th Ministerial Meeting (1992)

Compiled by AIST, Technology Research and Information Division [1992]

Figure 3-7 : Policy statement on technology and the economy

Overall Policy Framework
- Crucial and central role of the firm for technological development
- Responsibility of governments for establishing an appropriate environment for technological development

Strengthening Innovation Capabilities

①Supporting Basic Research
- Raising public funding to basic research
- Facilitating and improving links between R&D activities of the public sector and the market

②Technology Diffusion within the Economy and Society
- Developing policy measures to facilitate technology diffusion particularly as reguards small and medium size entreprises
- Removing market impediments

③Human Resources Development
- Critical importance of human resource development mobility for the competitiveness of firms and countries
- Need for policies in various area to be supportive and coordinated
- Facilitating and improving links between public sector and private sector

Globalisation of Science and Technology

①Private R&D Support and International Access to Science and Technology
- Deepening analysis of government support to private sector R&D and to "strategic technologies"
- Need for guidelines on government support to R&D
- Equal access for domestic and foreign-controlled firms to publicly funded research

②National Practices and International Convergence
- Potential for increased international friction arising from some differences in national policies
- Determination to address these issues at a multilateral level
- Deepening analysis of policies related to countries' competitive positions and interconnections between policies in various area
- Need to develop additional "rules of the game"

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